

NATIONAL ENGINEERING AND SCIENCE POLICY

HEARING
BEFORE THE
SUBCOMMITTEE ON
SCIENCE, RESEARCH AND TECHNOLOGY
OF THE
COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
NINETY-SEVENTH CONGRESS
FIRST SESSION

DECEMBER 14, 1981

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NATIONAL ENGINEERING AND SCIENCE POLICY

MONDAY, DECEMBER 14, 1981

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY,
Middletown, Pa.

The subcommittee met, pursuant to call, at 9:13 a.m., at Capitol Campus, Pennsylvania, State University, Middletown, Pa., Hon. Allen Ertel presiding.

Present: Representatives Walgren and Shamansky.

[Opening statements of Hon. Doug. Walgren and Hon. Allen Ertel follow:]

OPENING STATEMENT OF
HON. DOUG WALGREN
PENNSYLVANIA FIELD HEARING ON
NATIONAL ENGINEERING & SCIENCE POLICY
DECEMBER 14, 1981

WE ARE CONVENING THE HEARING TODAY AT THE REQUEST OF MY DISTINGUISHED COLLEAGUE AND FELLOW PENNSYLVANIAN, CONGRESSMAN ALLEN ERTEL, IN ORDER TO ADDRESS THE IMPORTANT ISSUES OF ENGINEERING AND SCIENCE POLICY. BEFORE TURNING THE CHAIR OVER TO MR. ERTEL I WOULD LIKE TO MAKE A FEW BRIEF REMARKS CONCERNING ONE ASPECT OF THESE POLICY ISSUES -- SCIENCE AND ENGINEERING MANPOWER.

OUR SUBCOMMITTEE, AS WELL AS THE FULL COMMITTEE HELD SEVERAL HEARINGS THIS YEAR TO ADDRESS THE CONCERNS OF SCIENCE AND ENGINEERING EDUCATION AS IT RELATES TO OUR NATION'S TECHNICAL HUMAN RESOURCE NEEDS. WE FOUND:

- O CURRENT PROJECTIONS SHOW A SHORTFALL BETWEEN 50-100,000 NEEDED ENGINEERS BY THE MID-1980's.
- O WE CURRENTLY LACK ROUGHLY 2,000 ENGINEERING FACULTY NECESSARY TO TRAIN AND EDUCATE OUR ENGINEERS; MORE

FACULTY ARE BEING ENTICED OUT OF THE UNIVERSITY AND INTO INDUSTRY, WORSENING THE PROBLEM;

- O LACK OF RESEARCH FACILITIES AND INSTRUMENTATION FOR RESEARCH AND EDUCATION THREATENS TO ERODE THE QUALITY OF EDUCATION NOW AVAILABLE TO OUR YOUNG ENGINEERS AND SCIENTISTS;
- O COMPARISONS WITH JAPAN AND RUSSIA POINT TO A NEED TO IMPROVE OUR OVERALL MATHEMATICS AND SCIENCE EDUCATION IN ALL THE PRE-COLLEGE LEVELS.
- O IN SUMMARY, WE FACE SERIOUS PROBLEMS IN THE SHORT AND LONG TERM IN MAINTAINING AN ADEQUATE SUPPLY OF OUR NATION'S SCIENTISTS AND ENGINEERS.

UNFORTUNATELY, THE RESPONSE OF THIS ADMINISTRATION IN ADDRESSING THESE AND OTHER RELATED PROBLEMS HAS NOT BEEN OVERWHELMING. IN LOOKING AT THE NATIONAL SCIENCE FOUNDATION BUDGET, WE SEE THE SCIENCE AND ENGINEERING EDUCATION DIRECTORATE HAS BEEN SLATED FOR ELIMINATION. OMB IS RECOMMENDING CUTS OF MORE THAN 50%

OF THE DEPARTMENT OF EDUCATION'S STUDENT LOAN PROGRAMS OF WHICH \$200 MILLION GOES TO THE EDUCATION OF YOUNG ENGINEERS IN THIS COUNTRY. THE DEPARTMENT OF EDUCATION'S ENTIRE EDUCATION RESEARCH COMPONENT IS SLATED FOR ELIMINATION.

THESE AND OTHER ACTIONS ARE BOUND TO HAVE LONG RANGE REPERCUSSIONS BOTH IN REGARD TO OUR NATIONAL ECONOMY AND IN THE STRATEGIC NEEDS OF THE NATION.

I AM VERY MUCH INTERESTED IN EXPLORING THESE AND OTHER ISSUES WITH OUR WITNESSES THIS MORNING. I LOOK FORWARD TO THOSE DISCUSSIONS.

I WOULD NOW LIKE TO TURN TO MY DISTINGUISHED FRIEND, ALLEN ERTEL. HE WILL CHAIR THE REMAINDER OF THIS SESSION.

OPENING STATEMENT
HON. ALLEN ERTTEL
PENNSYLVANIA FIELD HEARING ON
NATIONAL ENGINEERING & SCIENCE POLICY
DECEMBER 14, 1981

THANK YOU, MR. CHAIRMAN. I AM DELIGHTED YOU HAVE BEEN ABLE TO JOIN WITH ME TODAY IN EXPLORING THE IMPORTANT ISSUES RELATED TO NATIONAL SCIENCE AND ENGINEERING POLICY AND THE EFFECTS OF THAT POLICY ON THIS NATION, AND MORE PARTICULARLY, THE STATE OF PENNSYLVANIA. AS YOU POINTED OUT, WE APPEAR TO HAVE A NUMBER OF SEVERE PROBLEMS NOW AND IN THE FUTURE REGARDING THE NATION'S TECHNICAL HUMAN RESOURCE NEEDS.

OUR PAST HEARINGS HAVE ALSO POINTED TO GROWING-CONCERNS IN A NUMBER OF OTHER SCIENTIFIC AND TECHNOLOGICAL AREAS. THESE INCLUDE:

- O THE PROBLEM OF OBSOLETE INSTRUMENTATION AND FACILITIES NECESSARY FOR ADVANCED RESEARCH AND EDUCATION;
- O THE TRANSFER OF TECHNOLOGY DEVELOPED THROUGH FEDERAL RESEARCH SUPPORT FROM THE LABORATORY AND INTO THE MARKETPLACE FOR PUBLIC BENEFIT;

- O THE PROBLEM OF PROMOTING GREATER INNOVATION AND PRODUCTIVITY THROUGH USE AND DEVELOPMENT OF SCIENCE AND TECHNOLOGY;
- O THE DEPENDENCE OF THE NATION'S ECONOMIC HEALTH AND REVITALIZATION ON A STRONG AND VITAL SCIENCE AND ENGINEERING BASE;
- O THE NEED FOR MAINTAINING CONTINUING PROGRAMS IN BASIC AREAS OF RESEARCH AND DEVELOPMENT, NOT ONLY IN THE PHYSICAL OR NATURAL SCIENCES SUCH AS PHYSICS AND CHEMISTRY BUT IN SUCH AREAS AS THE SOCIAL AND BEHAVIORAL SCIENCES AND ECONOMICS;
- O WE ALSO SEE A NEED FOR SUCH PROGRAMS AS UNIVERSITY-INDUSTRY COOPERATION; FOR INTERGOVERNMENTAL SCIENTIFIC AND TECHNOLOGICAL COOPERATION AND FOR A BROAD RANGE OF INNOVATION AND SMALL BUSINESS DEVELOPMENT PROGRAMS;

EACH OF THE AREAS I HAVE MENTIONED HAS SEEN SEVERE CUTBACKS OR ELIMINATION IN THE CURRENT FEDERAL BUDGET. EACH HAS BEEN ALLOCATED

LOWERED PRIORITY AFTER LITTLE OR NO POLICY ANALYSIS. MANY OF THESE PROGRAMS HAVE, IN FACT, SUFFERED REDUCTIONS AND ELIMINATIONS DESPITE THE ADVICE OF THE ADMINISTRATION'S OWN SCIENCE POLICY EXPERTS.

I BELIEVE THESE CHANGES WILL CAUSE SEVERE AND LONG TERM HARDSHIPS ON THE OVERALL HEALTH OF THE NATION'S SCIENCE AND ENGINEERING RESEARCH AND EDUCATION PROGRAMS. IN PARTICULAR, I THINK THIS STATE'S INSTITUTIONS OF HIGHER EDUCATION AS WELL AS ITS HIGH TECHNOLOGY INDUSTRIES WILL SEE UNNECESSARY AND ILL-CONSIDERED LONG TERM EFFECTS OF THESE FEDERAL BUDGET CUTS.

I AM VERY MUCH INTERESTED IN HEARING FROM OUR WITNESSES THIS MORNING AND LOOK TO TAKING THAT INFORMATION BACK TO OUR COLLEAGUES IN WASHINGTON.

Mr. WALGREN. Let me welcome you to this hearing and express my appreciation as chairman of the Subcommittee on Science, Research and Technology, for agreeing to provide testimony on the issue of a national engineering and science policy.

We're convening today at the specific request of Allen Ertel, the Congressman who represents this area of Pennsylvania.

Before turning the chair over to Mr. Ertel, I would like to make a few comments of my own. I represent a district from Pittsburgh, Pa., so our interests are not all that different. I have a tremendous amount of respect for the momentum and the initiative that Congressman Ertel has brought to the Science and Technology Committee. I am chairman more by the roll of the dice than by anything else in our procedures. Pennsylvania, I think, should be especially proud of the quality of the people they have sent to Congress, particularly Mr. Ertel, and the contribution that he has made to the Committee on Science and Technology.

Our subcommittee, as well as the full committee, has held a number of hearings in the area of engineering and science policy. We have authorizing jurisdiction over the National Science Foundation and general concern for basic scientific research and development policies for the Nation. We found in those hearings that there is a real crisis coming, if it is not already upon us, and that the administration is advocating policies that to many of us seem to go clearly in the wrong direction.

The current projections show a shortfall of between 50,000 and 100,000 engineers by the mid-1980's. We are short 2,000 engineering faculty necessary to train and educate our engineers, and these faculty are nowhere on the horizon. Faculty is being drained from the engineering schools, according to testimony that has been presented to us in other hearings. I hope this will be addressed today. Most of this loss of faculty from the university community to the private sector is due to the greatly increased demand for trained engineers.

The lack of facilities and instrumentation for academic research threatens to erode the quality of education now available to young engineers. All comparisons with the countries with which we will be competing in a worldwide economy indicate that we will come up very short in mathematics and engineering education. This is something that cannot be fixed in a matter of years, but, rather, only decades and then only if we begin addressing that kind of a shortfall, now.

Unfortunately, the response of the administration in addressing these and other related problems, has not been promising. This is my personal view, and I would think is the view of any reasonable person.

If we look at the National Science Foundation budget, we see that the science and engineering education directorate has been slated for elimination. OMB is recommending cuts of more than 50 percent of the Department of Education's student loan programs, of which \$200 million goes to education of young engineers. And the Department of Education's entire education research component is slated to be zeroed out.

These and other actions are bound to have long-range repercussions, both in regard to our national economy and to the strategic needs of the country.

I think that it certainly is time for the people who understand the influence of research on our economy to speak out, which is starting to happen. There was a convocation in Washington, under the auspices of the National Academy of Sciences, in which you start to see the ideas expressed that what this Nation needs is investment and, therefore, it needs more, rather than less, governmental effort in the area of basic research. This seems only reasonable.

I hope that through these kinds of hearings, we can start to make that point in public so that we will find our policies shifting in the direction of more investment in basic research by the Government. This is particularly important in those areas where we all admit that the private sector is not a viable alternative. We would hope that we can change the direction of public policy, before we suffer a national loss.

With that, I want to turn the chair of this hearing over to my colleague, and express my appreciation for your having both set up this hearing and gathered the witnesses. We look forward to digesting and trying to communicate the presentations to other colleagues in Washington. Allen.

Mr. ERTEL [presiding]. Thank you very much, Doug. I appreciate your kind comments. I am certainly happy that you were able to bring the subcommittee up here today to explore the important issues relating to national science and engineering policy and the effects of that policy on this Nation, and particularly, the State of Pennsylvania. As you know, Doug, we have with us Congressman Shamansky, as well.

Pennsylvania is one of the leading educational States in the Nation. It has outstanding educational institutions and many of those institutions are heavily committed to science and engineering education. And as you pointed out, we appear to have a number of severe problems, now and in the future, regarding the Nation's human resource needs in areas of science and engineering.

Our past hearings have pointed to growing concerns in a number of scientific and technological areas. These include, among others, the problem of obsolete instrumentation and facilities necessary for advanced research and education; the transfer of technology developed through Federal research support from the laboratory and into the marketplace; the problem of promoting greater innovation and productivity by applying developments in science and technology; the dependence of the Nation's economic health and revitalization on a strong vital science and engineering base; and the need for maintaining continuing programs in basic areas of research and development, not only in the natural sciences such as physics and chemistry, but in such areas as the social and behavioral sciences and economics. I think we also have a need for such programs as university-industry cooperation, for intergovernmental scientific and technological cooperation and for a broad range of innovation and small business development programs.

Each of those areas I have just mentioned has had severe cut-backs or have been eliminated in the current Federal budget. Each

has been allocated lower priority or elimination, after little or no policy analysis whatsoever. Many of these programs have, in fact, suffered reductions and eliminations, despite the advice of the administration's own science policy experts.

I believe these changes will cause severe and long-term hardships on the overall health of the Nation's science and engineering research and education programs. In particular, I think this State's institutions of higher education, as well as its high technology industries, will see unnecessary and ill-considered long-term effects of these Federal budget cuts.

And I am certainly interested in hearing what you have to say about these particular areas. I am very much concerned about it, because as we continue to cut back these areas, we are selling our educational and engineering institutions, and with them the future of America. There is a spiraling effect as we continue to cut back in these areas. What happens is the next generation is influenced by these policies and their effects are propagated. Hopefully, we can change this policy, if, in fact, my analysis is correct. I am interested in hearing what you, the people in the educational institutions, and those who have a great deal of influence and thought a great deal about the science policy of this country, have to say about these questions. So we're very happy to see the list of witnesses we have today, and to hear their views as to what is happening in Washington.

With that opening statement, I think what we'd like to do is start with the panel. The first three will be Dr. Barry Maxwell, who is dean, College of Engineering, Bucknell University; Dr. Richard C. Cunningham, vice president for research and graduate studies, Pennsylvania State University; Dr. Bernard P. Sagik, vice president for academic affairs at Drexel University. If they would come forward, we would be happy to have your testimony. We will start with Dr. Maxwell.

STATEMENTS OF DR. BARRY MAXWELL, DEAN, COLLEGE OF ENGINEERING, BUCKNELL UNIVERSITY; DR. RICHARD C. CUNNINGHAM, VICE PRESIDENT FOR RESEARCH AND GRADUATE STUDIES, PENNSYLVANIA STATE UNIVERSITY; AND DR. BERNARD P. SAGIK, VICE PRESIDENT FOR ACADEMIC AFFAIRS, DREXEL UNIVERSITY

Dr. CUNNINGHAM. Do you have copies of the paper? I'm going to be referring to a figure.

Mr. ERTEL. We have copies, I believe, of every submitted document. You may either read your document or may summarize it. The written testimony will be incorporated in the record, without objection. Dr. Maxwell.

Dr. MAXWELL. Thank you, Mr. Ertel, and Mr. Walgren. I think you both stole some of our thunder here this morning with your opening remarks. However, I think it probably won't hurt for you to hear the viewpoint of the engineering and science institutions of Pennsylvania.

I am here this morning to provide insights on this matter that we are dealing with from two perspectives. First and foremost, from my perspective as dean of the College of Engineering at Buck-

nell; and, second, from the perspective of this year's president of the Association of Engineering Colleges of Pennsylvania, a group of 15 colleges and universities across the State which offer undergraduate and graduate engineering education.

I am going to focus my remarks this morning on engineering education and research since these are areas I'm most comfortable with and I am most knowledgeable about. However, much of what I have to say relates either directly or indirectly to laboratory science education as well.

I am sure you are aware of what many perceive to be the crisis in engineering. It has been defined and described and rationalized and analyzed by a broad spectrum of individuals and organizations and blue ribbon panels for a number of months now. Not surprisingly, the root of the problem in engineering education appears to be money, and that is, after all, what we're concerned with this morning. Frankly, I think there is probably too much talk of crisis with respect to this issue, but we all seem to thrive on a good crisis. And since we are responding to the situation as if a crisis existed, I won't tamper with the term.

What is of primary concern, regardless of whether we call it a crisis or not, is that there are serious, festering problems in engineering education, and they are likely to get worse before they get very much better.

Simply stated, at the very time when the engineering profession and industry have increased their demands for higher quality and larger numbers of engineering graduates, and at a time when our universities and colleges are graduating record numbers of engineers, our faculties are becoming understaffed and our facilities are becoming increasingly outmoded. The replacement stream of graduate students that should be replenishing our faculties has been significantly reduced at a time when it should be increasing to help meet the challenges we face in the world technological marketplace. In short, the engineering education system has been allowed to fall into considerable disrepair during recent years. The problem is complex and involves interrelated factors which differ with time, geographical location, university setting, and national and global factors.

Let me cite some specific national and statewide examples and statistics to help illustrate the problems, although judging from your introductory comments, I am sure you have heard them all before.

Point 1. A recent national study found that as of the fall 1980, there were a little over 16,000 permanent full-time engineering faculty positions in the 244 engineering schools in this country. And that at that time almost 10 percent of the positions were unfilled at the beginning of the fall 1980 term. Of these unfilled positions, 45 percent have been vacant since 1979.

As you know, the problem is worse in electrical engineering and computer engineering, where the shortage is reputed to be somewhere in the range of 50 percent. The faculty vacancy situation in the State of Pennsylvania is very similar to the national situation. The result of a recent study conducted by the Pennsylvania engineering schools, shows that of the 7 schools responding, 74 faculty

positions remain unfilled at this time across the State, representing approximately 10 percent of the total faculty positions.

Point 2. During the 1979-80 academic year, almost 400 engineering faculty across the country voluntarily left academia for full-time employment in industry, almost 3 percent of all permanent engineering faculty. Discussions with my colleagues in the Pennsylvania Engineering Dean's Association confirm that this percentage is consistent with the voluntary departments in this State, as well, although I have no firm statistics in this regard.

Point 3. The national study mentioned previously also revealed that over half of all or institutions reported a substantial decrease in their ability to recruit and retain engineering faculty over the past 5 years, 80 percent reported that staffing difficulties had led to increased teaching loads, 76 percent reported a consequent decrease in the quality of research, and 80 percent of the responding institutions firmly believe that the quality of instruction has suffered.

I'm sure my colleagues in Pennsylvania would agree that we see the same problem in this State.

Point 4. Engineering laboratory teaching facilities across the Nation are largely based on the technology of the early 1960s, when many of our facilities were built and equipped with state-of-the-art equipment and instrumentation. Unfortunately, the maintenance of university facilities has typically been deferred over the last two decades and they have been allowed to deteriorate in both physical condition and quality of equipment and instrumentation.

The problem was further aggravated by substantial technological developments over the past two decades, and the inability of our institutions to meet the necessary equipment acquisition and replacement costs.

A rough rule of thumb exists which states that based upon a 6-7 average lifetime of instructional laboratory equipment, approximately \$1,500 per engineering baccalaureate degree is required as an annual replacement cost.

To illustrate the equipment acquisition and replacement problem in the State of Pennsylvania, the Association of Engineering Colleges of Pennsylvania has recently collected data on the funds required to renew and update our laboratory equipment for undergraduate engineering instruction and research and graduate instruction. Data from 9 engineering schools which responded to the survey, show that approximately \$12 million will be required for renewal and updating of undergraduate lab equipment over the next 3 to 5 years, and that approximately \$18 million would be required in the research and graduate education area alone.

It is clear that we have a problem in the State of Pennsylvania in this regard, and the same equipment renewal and updating problem certainly exists nationally.

Point 5. On the faculty salary issue, academic salaries have not kept pace with inflation over the past decade, and on the average, industrial salaries are significantly higher than academic salaries when based upon similar years of experience. Further, current starting salaries of graduate engineers are in some cases in excess of those of experienced faculty, and in many cases higher than the

salaries of beginning faculty members. As a result, recruitment and retention of faculty is extremely difficult and uncertain.

Recent data from the Pennsylvania engineering schools show that the current average salaries for full professors, associate professors, and assistant professors in this State are approximately \$37,000, \$28,000, and \$24,000, respectively. For comparison purposes, the average starting salary of students graduating from Bucknell University last June was \$23,232, only \$744 less than the average assistant professor's salary in the State. Several of our graduates received salaries which were comparable to the statewide average associate professor salary.

Point 6. With respect to engineering degree statistics, engineering colleges across the country have increased their production of baccalaureate and masters degrees during the past years. Baccalaureate degrees, for instance, have increased by almost 54 percent, while at the same time, Ph. D. production has decreased by approximately 13 percent. Even though our BS degree production has increased significantly in recent years, the number of engineering degrees is still a smaller percentage of the total degrees granted than the percentages for West Germany, Japan, and several other major nations. According to UNESCO statistics, the United States not only trails Japan in the percentage of engineers graduating, but trails in absolute numbers as well. In 1979, for instance, almost 66,000 men and women earned engineering degrees in Japan. In the United States the number was about 55,000.

I hope it is clear from my preceding remarks that we have problems in engineering education which have existed for some time and they are not likely to go away very soon—problems that you already know about obviously, high enrollments, low faculty salaries, decreased Ph. D. production, industrial competition for faculty, poor laboratory facilities and so on. The central question, it seems to me, is what is the root of the problem and what can we do about it? The specific questions we are concerned with this morning, however, are do the reductions in the 1982 Federal budget impact the problem and, if so, how? Clearly, the answer to the impact question is, "yes, budget reductions do have an impact, but they are really not the cause." As to how, that's a more complex and somewhat more difficult question to answer.

There are some who will argue that the simple answer is money. Plug more money into undergraduate and graduate education and the problems will go away. In a simplistic sense, this is probably correct, but the solution is far more complex than that. It seems to me that most of the problems in engineering education, particularly undergraduate engineering education, stem from the current unattractiveness of an academic career as viewed by current and potential faculty members. An academic career is currently unattractive to many faculty precisely because of the problems already identified: Low salaries, high teaching loads, poor equipment, and so forth.

An academic career is made more unattractive for many by the requirements and criteria established by most institutions for tenure and public scholarship. A new bachelor's degree recipient in engineering may consider a career in teaching, but recognizes that he or she must devote 3 or 4 years to studying for a Ph. D. degree,

take a substantial pay cut when the degree is completed, take on exceptionally high teaching loads, work with outdated laboratory equipment and then be evaluated for tenure and promotion, and perhaps be rejected by faculty committees and administrators who are frequently insensitive to the current problems in engineering education.

In short, that new engineering degree recipient will often conclude that teaching is not a very attractive career option.

So what do we in education and government and industry do about the problem? The solution will obviously not be easy, and it will not be inexpensive. There have been, however, many good first steps toward a solution. Industry is now beginning to assume an active role because it clearly recognizes that it has much to lose if the problem grows much worse. I am sure you are aware of the many industrial efforts and programs, which have been initiated across the country, to help reduce the severity and growth of the problem, and which in the long term should make an academic career more attractive to the current as well as the next generation of engineering instructors.

With respect to the university environment, perhaps one of the most frustrating aspects of the current situation is that outside the engineering schools and the science departments few senior university administrators are really aware of the problem. It is for this reason that the following resolutions were made at this year's Engineering Deans Institute, held in San Antonio, Tex., in mid-April.

The Engineering College Council first, encourages university administrators to authorize higher salaries for engineering faculty; second, recommends AAES and ASEE develop an authoritative and comprehensive data base for reliable analyses and projections of the need for engineering faculty; third, resolves that the reality and consequence of the faculty shortage be brought to the attention of the people of the United States; and, lastly, calls for a multifaceted attack on the problem of deteriorating and obsolete engineering school laboratory equipment and facilities.

The hope is that these resolutions will give more credibility to requests an engineering dean may make to a university president for a greater proportion of internal resources, and will show the problems of engineering education as a nationwide blight on engineering colleges, and not simply isolated cases.

To further clarify the scope and depth of the problem, the president of the American Association of Engineering Societies sought to make university presidents more aware of engineering education's problems by sending them a letter in mid-June of this year. In addition to making the presidents aware of the problems, the letter also encouraged them to take every opportunity in their State to support actions that would benefit engineering education, and to look much more closely at the allocation of resources on their campuses, and make appropriate adjustments.

Since most institutional budgets for the current academic year were finalized well before these latest initiatives took place, it is really too early to know what their effect may be. It is clear, however, that senior university officials are more aware of the problems than they were before.

Now to the governmental role in the current problems. It is fair to say that the programs of greatest interest to engineering and science education have not fared at all well in the recent Federal budget cuts. The programs of greatest value to engineering schools and science departments, particularly at the undergraduate level, are those which provide funds for renovation and acquisition of instructional and research equipment, and for engineering and science education. The programs typically administered by NSF, DOE, and NIH have either been eliminated from the 1981 Federal budget or certainly sharply curtailed.

National Science Foundation programs, which have been particularly important to institutions like Bucknell, which place concerted effort on the undergraduate engineering and science education, include the instructional scientific equipment research participation program, and the comprehensive assistance to undergraduate scientific education program.

Elimination or curtailment of these and other programs will result in fewer grants, smaller awards, and stiffer competition for limited funds, with the inevitable result of a significant reduction in new engineering and science course development, a reduction in the purchase of instructional and research equipment, fewer traineeships and fellowships in engineering and science education, and a curtailment of instrumentation acquisition and development.

These cutbacks are taking place at precisely the time when the demand for engineering graduates is increasing, enrollments are at an all-time high, faculties are overworked, and laboratory facilities are becoming outmoded. The effects will be felt by all institutions across the country, but perhaps most strongly at the undergraduate private colleges and universities who are not involved in large research operations, and who have not yet entered into large-scale cooperative programs with industry to help take up the slack.

I hope it is clear from my preceding remarks that we have problems in engineering and science education, and by "we" I mean academia, industry, and Government. Clearly, we must all share the responsibility for solving the problems. Academia must continue to take the initiative to resolve the problems and must continue to focus on the instructional and reward aspects of the educational system. Industry must continue to progressively participate in the solution process since it is the immediate beneficiary of the educational system, and Government must not shirk its role and responsibility to ameliorate the problems through grant funds invested in laboratory equipment, and engineering and science education.

I wish to thank you for the opportunity to speak before you this morning and to share some of my thoughts and some of my concerns regarding this matter. Thank you.

[The prepared statement of Dr. Maxwell follows:]

STATEMENT OF DR. BARRY R. MAXWELL, DEAN, BUCKNELL UNIVERSITY

Thank you for inviting me to testify this morning on an issue which is of very great concern to those of us in higher education in this state--namely, the impact of the federal budget reductions on engineering and scientific research and education in the State of Pennsylvania. I am here this morning to provide insights on this matter from two perspectives--first and foremost from my perspective as Dean of the College of Engineering of Bucknell University (a small, private university of 3200 students with a strong College of Engineering which offers undergraduate and graduate engineering instruction to 670 highly qualified students), and secondly from my perspective as this year's President of the Association of Engineering Colleges of Pennsylvania (a group of 15 colleges and universities across the state which offer undergraduate and graduate engineering education). I am going to focus my remarks this morning on engineering education and research, since these are areas I am most comfortable with and am most knowledgeable about. However, much of what I will have to say relates either directly or indirectly to laboratory science education as well.

I am sure you are aware of what many perceive to be the "Crisis in Engineering Education". It has been defined, described, rationalized, and analyzed by a broad spectrum of individuals, agencies, organizations, and blue ribbon panels for a number of months now. Not surprisingly, the root of the problems in engineering education appears to be money, and that is, after all, what we are concerned about this morning. Frankly, I think there is probably too much talk of "crisis" with respect to this issue, but we all seem to like a good crisis, and since we are responding to the problem as if a crisis existed, I shall not tamper with the term. What is of primary concern, regardless of whether we call it a crisis or not, is that there are serious, festering problems in engineering education, and they are likely to get worse before they get better.

Simply stated, at the very time when the engineering profession and industry have increased their demands for higher quality and larger numbers of engineering graduates, and at a time when our universities and colleges are graduating record numbers of engineers, our faculties are becoming understaffed and our facilities are becoming increasingly outmoded. The replacement stream of graduate students that should be replenishing our faculties has been significantly reduced at a time when it should be increasing to help meet the challenges we face in the world technological marketplace. In short, the engineering education system has been allowed to fall into considerable disrepair during recent years. The problem is caused by complex and interrelated factors which differ with time, geographical location, university setting, and national and global factors.

Let me sight some specific national and statewide examples and statistics to help illustrate the problems, although I am sure you have heard them all before:

- A recent national study funded by the National Science Foundation, U.S. Department of Education, and the National Endowment for the Humanities, found that as of Fall 1980 there were approximately 16,200 permanent full-time engineering faculty positions in the 244 engineering schools in this country, and that almost 10 percent of these positions were unfilled at the beginning of the Fall 1980 term; of these unfilled positions, 45 percent had been vacant since 1979. The problem is worse in electrical engineering and computer engineering; here the shortage is reported to be closer to 50 percent.

The faculty vacancy situation in the State of Pennsylvania is very similar to the national situation. The results of a recent survey conducted of Pennsylvania engineering schools showed that of the seven schools responding, 74 faculty positions remain unfilled at this time across the State, representing approximately 10 percent of the total faculty positions.

- During the 1979-80 academic year, almost 400 engineering faculty across the country voluntarily left academia for full-time employment in industry--almost 3 percent of all permanent engineering faculty. Discussions with my colleagues in the Pennsylvania Engineering Dean's Association confirm that this percentage is consistent with the voluntarily departures in this state as well, although I can provide you with no firm statistics in this regard.
- The national study previously mentioned also revealed that over half of all institutions reported a substantial decrease in their ability to recruit and retain engineering faculty over the past five years, 80 percent reported that staffing difficulties have led to increased teaching loads, 76 percent reported a consequent decrease in the quality of research, and 80 percent of the responding institutions believe that the quality of instruction has declined. I am sure my colleagues in Pennsylvania would agree that we see the same problem in this state.
- Engineering laboratory teaching facilities across the nation are largely based on technology of the early 1960's, when many of our facilities were built and equipped with state-of-the-art equipment and instrumentation. Unfortunately, the maintenance of university facilities has typically been deferred over the last two decades, and they have been allowed to deteriorate in both physical condition and quality of equipment and instrumentation. The problem is further aggravated by substantial technological developments over the past two decades, and the inability of our institutions to meet the necessary equipment acquisition and replacement costs. A rough rule of thumb exists which states that, based upon a 6-7 year average lifetime of instructional laboratory equipment, \$1500 per engineering baccalaureate degree is required as an annual replacement cost.

To illustrate the equipment acquisition and replacement problem in the State of Pennsylvania, the Association of Engineering Colleges of Pennsylvania has recently collected data on the funds required to renew and update our laboratory equipment for undergraduate engineering instruction, and research and graduate instruction. Data from nine engineering schools which responded to the survey show that approximately \$12,000,000 would be required for renewal and updating of undergraduate laboratory equipment over the next 3-5 years, and that approximately \$18,000,000 would be required in the research and graduate education area. It is clear that we have a problem in the State of Pennsylvania in this regard, and the same equipment renewal and updating problem exists nationally.

- On the faculty salary issue, academic salaries have not kept pace with inflation over the past decade, and on the average, industrial salaries are significantly higher than academic salaries, when based upon similar years of experience. Further, current starting salaries of graduate engineers are, in some cases, in excess of those of experienced faculty, and in many cases higher than the salaries of beginning faculty members. As a result, recruitment and retention of engineering faculty is extremely difficult and uncertain.

Recent data from the Pennsylvania engineering schools show that the current average salaries for full professors, associate professors, and assistant professors in this state are \$37,064, \$28,092, and \$23,976, respectively. For comparison purposes, the average starting salary of students graduating from Bucknell University last June was \$23,232, only \$744 less than the average assistant professor salary in this state. Several of our graduates received salaries comparable to the statewide average associate professor salary.

- With respect to engineering degree statistics, engineering colleges across the country have increased their production of baccalaureate and masters degrees during the past five years. Baccalaureate degrees, for instance, have increased by almost 54 percent, while at the same time PhD production decreased by approximately 13 percent. Even though our baccalaureate degree production has increased significantly in recent years, the number of engineering degrees is still a smaller percentage of the total degrees granted than the percentages for West Germany, Japan, and several other major nations. According to UNESCO statistics, the United States not only trails Japan in percentage of engineers graduated, but trails in absolute numbers also. In 1979, 65,422 men and women earned engineering degrees in Japan. In the U.S. the number was 54,600.

I hope it is clear from my preceding remarks that we have problems in engineering education which have existed for some time, and they are not likely to go away very soon--problems having to do with high enrollments, low faculty salaries, decreased PhD production, industrial competition for faculty, poor laboratory facilities, etc. The central question is, it seems to me, what is at the root of our problems and what can we do? The specific questions we are concerned with this morning are, however, do the reductions in the 1982 federal budget impact the problems, and if so, how? Clearly, the answer to the impact question is yes, budget reductions do have an impact, but they are not the cause. As to how, that is a more complex and somewhat more difficult question to answer.

There are some who argue that the simple answer is money--plug more money into undergraduate and graduate education and the problems will go away. In a simplistic sense this is probably correct, but I believe that the solution is far more complex than that. It seems to me that most of the current problems in engineering education, particularly undergraduate education, stem from the current unattractiveness of an academic career as viewed by current and potential faculty members. An academic career is currently unattractive to many faculty precisely because of the problems already identified--low salaries, high teaching loads, poor equipment, industrial competition, etc. An academic career is made more unattractive for many by the requirements and criteria established by most institutions for tenure and published scholarship. A new bachelor's degree recipient in engineering may consider a career in teaching, but recognizes that he or she must devote 3-4 years to studying for a PhD degree, take a substantial pay cut when the degree is completed, take on exceptionally high teaching loads, work with outdated laboratory equipment, and then be evaluated for tenure and promotion (and perhaps rejected) by faculty committees and administrators who are frequently insensitive to the current problems in engineering education. In short, that new engineering degree recipient will often conclude that teaching is not an attractive career option.

So what do we in education, government and industry do about this problem? The solution will not be easy and it will not be inexpensive. There have been, however, many recent good first steps towards the solution. Industry is beginning to assume an active role because it clearly realizes it has much to lose if the problem grows much worse. I am sure you are aware of many of the recent industrial efforts and programs which are directed at various aspects of the problems in engineering education:

- The Exxon Education Foundation has recently granted \$15 million to 66 engineering schools to establish 100 teaching fellowships and 100 faculty salary supplements. Organizations such as the Sun Company, Amoco Foundation, and others have established similar, but less ambitious programs to help alleviate faculty shortages.
- Dow Chemical has announced it has more than doubled its educational funding because of engineering education's problems. Its funding is being targeted for such areas as industrial fellowships, student loans, matching grants, etc.
- Eight companies (AT&T, DuPont, Exxon, General Electric, General Motors, GTE, IBM and Union Carbide) have contributed funds to hire an ASEE Staff Executive to coordinate efforts aimed at solving the engineering faculty shortage.

There are a variety of other industrial and educational cooperative programs being initiated across the country which will help reduce the severity and growth of the problem, and which should make an academic career more attractive to the current and next generation of engineering educators.

With respect to the university environment, perhaps one of the most frustrating aspects of the current situation is that, outside the engineering schools and science departments, few senior university administrators are aware of the problems. It is for this reason that the following resolutions were made at this year's Engineering Dean's Institute, held in San Antonio, Texas in mid-April.

The Engineering College Council:

- encourages university administrators to authorize higher salaries for engineering faculty,
- recommends AAES and ASEE develop an authoritative and comprehensive data base for reliable analyses and projections of the need for engineering faculty,
- resolves that the reality and consequence of the faculty shortage be brought to the attention of the people of the United States, and
- calls for a multifaceted attack on the problem of deteriorating and obsolete engineering school laboratory equipment and facilities.

The hope is that these resolutions will give more credibility to requests an engineering dean may make to a university president for a greater proportion of internal resources, and will show the problems of engineering education as a nationwide blight on engineering colleges, and not simply isolated cases.

To further clarify the scope and depth of the problems, the President of the American Association of Engineering Societies (AAES) sought to make university presidents more aware of engineering education's problems by sending them a letter in mid-June of this year. In addition to making the presidents aware of the problems, the letter encouraged them to take every opportunity in their state to support actions that would benefit engineering education, and to look more closely at the allocation of resources on their campuses, and make adjustments.

Since most institutional budgets for the current academic year were finalized well before these latest initiatives took place, it is too early to know what their effect may be. It is clear, however, that senior university officials are more aware of the problems in engineering education than they were before.

Now to the governmental role in the current problems. It is fair to say that the programs of greatest interest to engineering and science education have not fared well in the recent federal budget cuts. The programs of greatest value to engineering schools and science departments, particularly at the undergraduate level, are those which provide funds for renovation and acquisition of instructional and research equipment, and for engineering and science education. These programs, typically administered by NSF, DOE, and NIH, have either been eliminated from the 1982 federal budget or sharply curtailed.

National Science Foundation programs which have been particularly important to institutions, like Bucknell, which place emphasis on undergraduate engineering and science education include:

- the Instructional Scientific Equipment Program (ISEP)--a program which provides up to \$20,000 a year, on a matching fund basis, for the purchase of new undergraduate scientific and instructional equipment.
- the Local Course Improvement Program (LOCI)--a program which assists in the design, preparation, and implementation of new course materials at the undergraduate level.
- the Undergraduate Research Participation Program (URP)--a program designed to bring talented and promising undergraduate students into scientific and engineering research activities and allow them to work directly with faculty.
- the Comprehensive Assistance to Undergraduate Scientific Education Program (CAUSE)--a program which provides up to \$250,000 over three years to help develop or strengthen the resources for undergraduate engineering and science programs at the undergraduate level.

Elimination or curtailment of these and other programs will result in fewer grants, smaller awards, and stiffer competition for limited funds, with the inevitable result of a significant reduction in new engineering and science course development, a reduction in the purchase of instructional and research equipment, fewer traineeships and fellowships in engineering and science, and a curtailment of instrumentation acquisition and development.

These cutbacks are taking place at precisely the time when the demand for engineering graduates is increasing, enrollments are at an all-time high, faculties are overworked, and laboratory facilities are becoming outmoded. The effects will be felt by all institutions across the country, but perhaps most strongly at the undergraduate private colleges and universities who are not involved in large research operations, and who have not yet entered into large-scale cooperative programs with industry to help take up the slack.

I hope it is clear from my preceding remarks that we have problems in engineering and science education, and by "we" I mean academia, industry, and government. Clearly, we must all share the responsibility for solving the problems. Academia must continue to take the initiative to resolve the problems and must continue to focus on the structural and reward aspects of the educational system, industry must continue to progressively participate in the solution process since it is the immediate beneficiary of the educational system, and government must not shirk its role and responsibility to ameliorate the problems through grant funds invested in laboratory equipment, and engineering and science education.

I wish to thank you for the opportunity to speak before you this morning and to share some of my views and concerns regarding this matter.

Mr. ERTEL. Thank you very much, Dr. Maxwell. We appreciate your comments. I am sure we will have a multitude of questions for you, but prior to that we will take the other two witnesses and then come back to question you as a panel.

I must say that I neglected to recognize Congressman Shamansky, and if he had any opening comments he wanted to make, although a bit delayed, we would be happy to have them.

Mr. SHAMANSKY. I'm happy to be here.

Mr. ERTEL. That is a very quick opening comment. And at this point we will recognize Dr. Cunningham, vice president for research and graduate studies, Pennsylvania State University, who will also be representing other groups, as well as the State university, as I understand.

Dr. CUNNINGHAM. Thank you, Congressman Ertel. At the Pennsylvania State University, I serve as vice president for research and graduate studies, and in addition to speaking for Penn State, my comments today are endorsed by five national associations—the Association of American Universities, the Association of Graduate Schools, the American Council on Education, the National Association of State University and Land-Grant Colleges, and the Council of Graduate Schools in the United States.

My background includes 9 years as professor and head of the Department of Mechanical Engineering at Penn State, and prior to that 10 years of industrial research experience.

My comments this morning will be largely on research and graduate studies. My comments on engineering education and computer science education will be brief since Dean Maxwell has already covered that material.

Penn State is one institution in a group broadly called research university. This identification is associated with dollar volume of research. Another characteristic is that a substantial percentage of the faculty is simultaneously engaged in research and teaching.

Our expenditures last year were \$68.5 million and more than 60 percent of this was from Federal sources. Further to Pennsylvania institutions, the University of Pennsylvania ranks No. 11 in the top 100; Penn State, 20; University of Pittsburgh, 33; Carnegie-Mellon, 67; and Temple, 82. These are measured in terms of Federal obligations for research and development, (NSF Report 98-308.)

Figure 1 in the printed material that you have is a curve showing Penn State's research expenditures for the past decade. Dollar volume more than doubled, from \$34 million to \$68 million. But the dashed-line curve shows that in fact we are still where we were 10 years ago.

To cope with inflation and inadequate resources we have had to recycle funds on a large scale. Money has been pulled back from colleges and from research programs. Over the past 5 years recycling has exceeded \$23 million. These funds are used mainly for salary increases and to pay rising operating costs, fuel oil being a prime example.

This curve on inflation impact explains why I wholeheartedly support Government efforts to get inflation under control, as indicated my written statement.

Basic research in the United States is largely accomplished in the universities. The rest is primarily in large equipment national

laboratories, such as Argonne. The basic research in our universities is almost entirely dependent on Federal agency sponsorship. National Institutes of Health and the NSF are prime examples.

The public tends to hear a great deal more about applied research because it is usually more interesting and understandable. But basic research in the long run is higher education's primary research contribution to society, even though we hear relatively less about it.

We have in the last 6 to 9 months gotten clear signals of basic research reductions. The National Science Foundation is reducing the number of awards to stay within their projected budget cuts. NIH is taking a somewhat different tack in reducing their funding, by 12 percent on a selective project-by-project basis.

Seventy percent of our research is sponsored. This means that it is based on proposals prepared by faculty members, who both teach and do research. A huge amount of work goes into these proposals. Ten years ago, our office of sponsored programs processed on average 60 proposals per month. This rate has now doubled to 120 per month, due in large part to the increasing competition for shrinking resources. We run harder to stay in place.

In the applied research area, we are also seeing severe reductions. Examples are the U.S. Bureau of Mines and the Office of Surface Mining, which are quite important to our College of Earth and Mineral Sciences. At the same time fellowship programs in mining and mineral engineering are being cut. And these are areas where industrial demand far outstrips the manpower supply.

Regarding the Department of Energy, we are apprehensive, to put it mildly. Last year our support from DOE totaled \$2.2 million for research projects, primarily fossil fuels, but also solar energy. This represents about 3 percent of our research expenditures, but it is an important 3 percent. It approaches our total National Science Foundation funding which was \$4.2 million. The predicted demise of the DOE would impact severely on us.

The connection between research and undergraduate and graduate degree programs is not well understood by the public. Research in a university setting is a good societal investment with important spinoff benefits. Faculty researchers not only tackle the basic research task of uncovering new knowledge or the applied research task of solving problems, they also provide the training grounds for the next generation of scientists and the next generation of design and R. & D. engineers.

Another spin-off: Our teaching laboratories in science and engineering are highly dependent on hand-me-down equipment inherited from sponsored research projects.

The media in the last year has carried an unprecedented amount of information on industry-university cooperative research initiatives.

During the past 25 years, industry has played an important but relatively minor role in academic research. National estimates indicate that about 4 to 5 percent of university research is supported by industry. Currently at Penn State, this level is approximately 10 percent, largely because of material science and energy research.

We recognize the opportunity and the need to seek additional ties to industry, in part to compensate for the present and antici-

pated decline in Government support. Toward this end, we have established a new office of industrial research and innovation. This office provides field contacts and serves as a broker, between industry and faculty to find mutual interests and to facilitate research agreements.

Industry-related research—particularly in applied research and engineering—would have a healthy effect by bringing firing line needs of industry to the attention of students and faculty.

Mr. ERTEL. What do you mean by that?

Dr. CUNNINGHAM. The industry for many years has criticized university research programs as being esoteric, too divorced from the more practical, more applied needs of industry. And the Government has had little success in moving new technology from Federal programs, for example, NASA, into the public sector to create new products.

Engineering education at the master's and Ph. D. level has been criticized as being too much a carbon copy of graduate programs in the sciences, with the result that inadequate attention is given to design experience vis-a-vis research.

I am not going to detail any of these rather radical new arrangements between industry and education. I do recommend a November 23 article in Chemical and Engineering News.

My comments on industrial support of research in universities has been quite positive, and we are in fact positive on this issue. But I would be remiss if I did not also point out that there are also serious problems which must be solved by the participants—industry and university—entering cooperative research arrangements.

The problems flow and from the simple fact that a university and a for-profit industry are two quite different institutions. They both serve society but in dissimilar ways.

Referring to the tables on industry-university cooperative research. I would like to compare university in the left-hand column and industry in the right-hand column. I will start with the issue of patent protection. In the left column, note that our patent program exists for three reasons. First, we must provide responsible management of inventors in order to accept funding from sponsors, whether it be industries or Federal agencies. Second, patents are an effective means of technology transfer, to move ideas from the bench to the public sector. Third, a patent is a tangible recognition of faculty creativity—as are publications—and they occasionally financially reward the faculty inventors as well.

Regarding ownership, we expect to take title to all patents resulting from research.

Turning to industry, companies may or may not patent a new development. In highly competitive areas, trade secrecy may be a more attractive as a means of getting a new product to market ahead of the competition. A patent is in fact a publication; it makes it easier for the competition to counter the advance.

Companies sponsoring research at a university expect to secure patent rights or to own the patent. We have a conflict which must be resolved on a case-by-case basis.

Trade secrecy: The very concept is alien to the purposes of the university, and, from a practical standpoint, we cannot guarantee in a contract protection of proprietary information to a sponsor.

When we have to, we will agree to make a best effort to protect proprietary information.

In contact, trade secrets are a way of life in industry, particularly in high technology areas.

Publication of research results is the next comparison. In the university, it is our No. 1 priority. Our reputation is largely dependent on publication in referred journals. In industry they permit publication only if they are certain that it's not going to help the competition.

The origins of research programs in university and industry are quite different, as sketched in the table.

Management of research: It is important to recognize that research is not managed in academia. The faculty principal investigator is responsible for administering the project. The university in approving proposals check to insure that we operate in accordance with university policy and sponsor policy. In industry, research is managed. It is generally highly applied or developmental in nature; basic research is rare. Industry expects tangible and profitable results within a few years or they drop the program.

Finally, consider the time cycle of a research program. Research on campus is affected by the academic calendars. The availability of graduate assistants impacts on research planning. The availability of faculty depends of course on teaching responsibilities and whether or not that individual can be spared. Industry is far more flexible. They can start and stop projects, hire people and fire people.

We have learned from experience that the differences I have reviewed briefly can be overcome if both parties are willing to work at it.

Another problem is apparent with industry as an answer to the demise of governmental support: Industrial interest tends to focus on a narrow range of technology. If you examine the many recent news articles, you will find that almost all of them are concerned with (a) genetic engineering or biochemical engineering, or gene-splicing—to cite some of the names applied—and to (b) integrated or chip electronics.

Both pose a problem, in that these technologies involve large and expensive equipment. They're capital-intensive. They operate at the cutting edge of technology, and, capital equipment rapidly becomes obsolete—an anathema for equipment-short universities.

Most universities follow, rather than lead, in the applied research areas of integrated electronics. Hewlett-Packard, for example, conducts courses, for university faculty members.

Universities certainly will continue to contribute at the basic end of the spectrum of genetic engineering, but the big equipment and capital-intensive nature at the applied end will be serious impediments, as in the integrated electronics field.

The difficulty or ease of industry-university arrangements are a function of whether the research is basic or applied. It is relatively easy in the area of basic research because publications are not as damaging. But as we move to the applied area, the problems that I reviewed in the table loom large.

I conclude by recommending tax incentives to counter the many disincentives for industrial sponsorship of on-campus research.

These incentives should be aimed at encouraging industry to sponsor basic research as well as applied research of more immediate usefulness.

The next subject I'd like to comment on overlaps Dean Maxwell's to some extent; namely, research facilities and instrumentation.

Sponsors of university research, from industry or the Government, expect to find not only the expertise in faculty and graduate students, but they expect to find up-to-date laboratories as well.

As Federal agencies reduce their funding levels, we fall further and further behind. High technology laboratory instrumentation is expensive to buy and maintain. Furthermore, it is soon made obsolete by the appearance of better instruments, in terms of power, accuracy, or speed of response.

A number of people who have visited universities have observed that by comparison with industry and with laboratories abroad, many of our laboratories are very decrepit indeed. The initiative of the National Science Foundation 3 years ago to assist universities in acquiring modern equipment was applauded. We recommend that this NSF program be revived.

The Association of American Universities issued a report 3 months ago, entitled "The Nation's Deteriorating University Research Facilities—A Survey of Recent Expenditures and Projected Needs in Fifteen Universities." Penn State participated in this survey. The report is available from the AAU. For convenience, I have attached the executive summary of that report to my written statement. It contains up-to-date evidence of the needs.

Regarding engineering and computer science education, I would like to underscore one point in the first paragraph of my comments. The NSF and other Federal agencies—it seems to be a Federal habit—have a policy of reporting on what they call science-engineering or "S/E" manpower. They lump together science and engineering. This produces distortions in the case of manpower supply and demand. You may be familiar with the October 1980 report to President Carter, "Science and Engineering Education for the 1980's and Beyond." Through professional societies, I was associated with the early drafts. The NSF and Education Department authors had some strange findings; namely, that, on average, there wasn't a faculty shortage.

If you dig into the figures, however, you find that "S/E" breaks down into two categories: One, all of the science disciplines except computer science, and two, computer science and engineering. The latter two have a great deal in common. Both are in a crisis situation in terms of faculty shortages, spiraling undergraduate enrollments yet level or declining graduate enrollments. Lucrative industrial job opportunities are weakening faculties and causing the inadequate level of Ph. D. level enrollments. In the final version of that report the facts were straightened out. But since that time I have noticed several press releases on manpower and the headlines again are S/E. They continue to lump together apples and oranges.

The National Science Foundation should separate these two quite different situations. It would help the public understand what is going on.

The use of fellowships and traineeships is recommended as a fix for the graduate enrollment problems in engineering and in computer science.

The Navy's initiative to set up fellowship programs with stipends of \$12,000 is on target, and we hope that the other areas of the DOD will follow suit.

This stipend level is quite an important factor. With salaries typically \$25,000 for baccalaureate graduates, a stipend of \$5,000 is very unattractive to a prospective graduate student. Increasing the stipend to the level of \$12,000 is essential.

I thank you for this opportunity to comment.

[The prepared statement of Dr. Cunningham follows:]

The Impact of the Federal Budget Reductions on Engineering
and Scientific Research and Education in Pennsylvania

Field Hearing Conducted by the Subcommittee on Science, Research, and Technology
of the Committee on Science and Technology, U.S. House of Representatives

Middletown, Pennsylvania, December 14, 1981

Statement by Richard G. Cunningham

At The Pennsylvania State University I serve as Vice President for
Research and Graduate Studies. In addition to speaking for Penn State,
my comments are endorsed by the following national associations:

AAU - Association of American Universities

AGS - Association of Graduate Schools

ACE - American Council on Education

NASULGC - National Association of State University and Land-Grant
Colleges

CGS - The Council of Graduate Schools in the United States

The Pennsylvania State University is one institution in a group broadly identified as "research university," usually measured in terms of dollar volume of research. Penn State's expenditures last year totaled \$68.5 million. More than 60% of this funding came from federal sources. We rank 20th among the top 100 institutions receiving federal sponsorship for research. Of interest to this Pennsylvania hearing is the fact that the University of Pennsylvania ranks number 11; University of Pittsburgh 33, Carnegie-Mellon University 67, and Temple University 82, in the top 100 institutions in the United States in terms of federal obligations for research and development. Source: NSF Report 81-308.

Figure 1 shows the growth of Penn State's research from \$34 million per year a decade ago to \$68.5 million in 1981. In constant 1972 dollars the plot shows that at best we are still where we were ten years ago. To pay essential faculty salary increases and to keep up with OPEC fuel oil, we have recycled \$25 million in our operating budget through stringent management in the past five years. Our research programs have been stunted and eroded by inflation. I wholeheartedly support government efforts to get inflation under control.

Basic Research versus Applied Research, and Cutback Effects

In the United States it is estimated that 80% of all basic research is accomplished in universities; most of the remainder is in

large-equipment national laboratories, e.g., Argonne National Laboratory. Virtually all of our basic research is funded by federal agencies; NIH and NSF are prime examples. The public receives good news coverage of universities' accomplishments in applied research, because it is usually more interesting and understandable to the lay public. But basic research in the long run is higher education's primary contribution to society.

In recent months, we have experienced the clear indications of basic research reductions. If the trend continues it will first impair research, and then our ability to attract and retain high-quality faculty and graduate students. The National Science Foundation is reducing the number of awards to stay within budgetary restrictions. The NIH is reducing their funding by 12% on a selective basis, project-by-project.

Most of our work is "sponsored research," based on proposals prepared by faculty members. A decade ago, our Office of Sponsored Programs processed 60 proposals per month. This rate has now doubled to 120 per month due in large part to the increasing competition for scarce dollars. Each proposal represents extensive preliminary research and literature study by the author(s). We run harder, to stay in place.

Turning to the applied areas, we are also seeing severe reductions. The U.S. Bureau of Mines and the Office of Surface Mining have cut their support of our coal research. Fellowship programs in mining and mineral engineering are being curtailed in an area where demand far outstrips the manpower supply. Regarding the Department of Energy, we are apprehensive,

to understate the case. Last year the DOE supported \$2.2 million in research covering fossil fuels to solar energy and other subject areas. DOE support has been comparable in magnitude to that from the NSF (\$4.2 m) and the predicted demise of the DOE will impact severely on us.

Research Contributions to Undergraduate and Graduate Programs

Research in a university setting is an investment with unparalleled fringe benefits. Research projects not only uncover new knowledge and solve practical problems; they are training grounds for the next generation of scientists and engineers. In addition, our instructional laboratories in high-technology areas are highly dependent on equipment inherited from sponsored research projects.

Industry-University Cooperative Research Initiatives

During the past 25 years industry has played important but relatively minor roles in academic research. National estimates are 4 or 5% of university research expenditures. At Penn State this level is approximately 10%, relatively high as a result of our work in materials and energy research.

Along with other schools, we recognize the opportunity and the need to shift to industrial support to compensate for the anticipated decline in government support. A year and a half ago we established our Office

of Industrial Research and Innovation. Object: To identify mutual interests between industrial corporations with problems and faculty members with requisite capabilities, in both basic and applied research areas. Results to date have been encouraging. We are optimistic that support from industry can be increased. Furthermore, this change will have a healthy effect by replacing some of the "ivy" with firing-line needs of industry.

The newspapers and news magazines have reported an apparent explosion of industrial sponsorship of university research, during the past year. I recommend for example the November 23 article in Chemical and Engineering News, which explores the good news and the bad news of this dramatic turn of events in university-industry research relations.

In addition to the positive aspects, I would be remiss if I did not also point out the serious problems inherent to university-industry cooperation, which flow from fundamental differences between the two organizations. Table I compares university and industry in terms of publication of research findings, patents, trade secrets, the initiation and management of research and the different time frames for conducting research. These differences are not trivial, but they can be overcome if both parties are willing to work at it. For example, we have made our patent policy more flexible to facilitate negotiations with industry. This was accomplished without compromising our principles or responsibility to the public.

Industrially sponsored research is not a panacea since industry is usually interested in a relatively narrow range of subjects. Genetic engineering or bio-chemical engineering or gene splicing and of course integrated "chip" electronics are the prime areas of ferment. To some extent, both pose a common problem in that these technologies involve large and expensive equipment. They are capital intensive, they operate at the cutting edge of technology and the equipment rapidly becomes obsolete. This setting is an anathema for universities. It is sobering to note that most universities follow rather than lead in the applied research areas of integrated electronics. Companies such as Hewlett-Packard and Texas Instruments conduct seminars and short courses for university faculty members to bring them up-to-date. Universities certainly will continue to contribute at the basic end of the spectrum of genetic engineering, but the big-equipment and capital intensive nature of the applied end will be serious impediments. Technical as well as many contractual problems--e.g., trade secrets--are circumvented when industry buys faculty expertise on a consulting basis. We encourage consulting agreements for their educational value to the faculty member. But the fringe benefits of graduate student support, manpower training, and laboratory upgrading to name a few which result from on-campus sponsored research are sadly missing under consultantship arrangements.

It follows from the Table I that industrial sponsorship of basic research is relatively easy to accommodate: Invention and patent problems are less pronounced and industrial sponsors are less restrictive about publication of results. Unfortunately, U.S. companies do very little basic research and they are disinclined to support basic research

in academe. Applied research when it involves new technology to create new products creates a worst-case scenario so far as patents and publications are concerned.

To counter the disincentives for industrial sponsorship of on-campus research, we recommend tax incentives. These should be aimed at encouraging industry both to sponsor basic research--which will be a new experience for most companies--and the familiar applied research of direct value to their enterprise.

Research Facilities and Instrumentation

Sponsors of university research--particularly those from industry--expect to find not only scientific and engineering competence but up-to-date laboratory facilities as well. As federal agencies such as the NSF and NIH reduce funding levels we fall further behind. High technology laboratory instrumentation and associated computers are expensive and they become obsolete in a few years time. Most university laboratories appear decrepit in comparison with industry and with laboratories abroad. Two years ago the National Science Foundation had planned a significant effort to assist universities in modernizing their laboratories but this funding has been one more casualty of the federal funding cutbacks.

This problem has been thoroughly studied by the Association of American Universities and a report was recently issued "The Nation's

Deteriorating University Research Facilities--A Survey of Recent Expenditures and Projected Needs in Fifteen Universities." This report is available from the AAU, but for convenience I have included as Appendix A the Executive Summary from that report. The findings are conclusive--we are facing severe problems, and the universities clearly lack the resources to correct a deteriorating situation.

Engineering and Computer Science Education

The National Science Foundation and other federal agencies have an unfortunate policy of lumping science and engineering ("S/E") together as one entity when reporting on educational matters, e.g., manpower supply and demand. One example is the October 1980 report "Science and Engineering Education for the 1980's and Beyond," released by the NSF and the U.S. Department of Education. Job markets and hence enrollments have been rising sharply for the past six years in engineering and in computer science. The demand has driven starting salaries to new records every year. Yet the first drafts of the NSF-D.Ed. report literally missed the boat by looking at averages for all science and all engineering disciplines. Fortunately the error was recognized in the final draft.

The field of computer science and virtually all disciplines in engineering are confronted with severe problems which can be summarized as follows: Job market demands which outstrip the supply, massive and growing undergraduate student enrollments, faculty, classroom and out-of-date laboratory facilities which are inadequate and ironically, underenrolled graduate programs. Currently engineering baccalaureate

graduates receive average salary offers of \$25,000. This salary is up to several thousand dollars higher than the going rate for Ph.D. assistant professors. As a result the proportion of B.S. graduates going on for advanced degrees has dropped sharply. A decade ago, fellowship and assistantship stipends paid approximately half of an engineering graduate starting salary. Today starting salaries have more than doubled, and stipends have remained static in the face of rampant inflation--another disincentive to consider the advanced study necessary for an academic career and for industrial opportunities in research and advanced design.

The picture is even more bleak than one at first recognizes, because nearly one half of the engineering graduate degree enrollments are foreign nationals most of whom will return to their native countries. We are failing to meet the demand for engineering faculty now, and projections indicate that this is going to worsen continually in the 1980s unless corrective action is taken. According to a recent American Council of Education study commissioned by the National Science Foundation, 1600 of 16,200 engineering faculty positions are currently unfilled because of the shortage. In an earlier (1980) estimate, the American Association of Engineering Societies and the American Society for Engineering Education estimated that 2500 out of 20,000 engineering faculty positions were vacant. In computer science, 16% of the faculty positions are vacant. All these figures are understatements in the sense that they refer to funded faculty positions. At Penn State, and I am sure most institutions, the number of funded faculty positions in computer science and in engineering are inadequate to handle the

avalanche of students pursuing baccalaureate degrees. A booklet "Data Related to the Crisis in Engineering Education," was published by the American Association of Engineering Societies, the American Society of Mechanical Engineers, and the American Society for Engineering Education (March 1981). It contains convincing facts and figures. One example: In 1979-80 only 56% of the engineering programs visited were accredited for the full six-year period. Out-of-date and inadequate laboratories were found in almost all cases.

We recommend support for fellowships and traineeships and for the university-based research programs which enable students to complete masters and doctoral degrees. In this connection, fellowship stipends should be \$12,000, i.e., approximately one-half of engineering starting salaries in industry today. Otherwise, the intended purpose of increasing graduate enrollments to provide advanced-level manpower for industry and for faculty talent in engineering and computer science will not be achieved.

Graduate fellowship programs are an effective way of meeting the manpower shortages in computer science and engineering. The recent revival of the NSF graduate fellowship program--which originally was to be terminated this year--is encouraging news. In November 1981 the funding increased from \$9.9 million to approximately \$15 million. This will permit increasing stipend levels from \$4900 to \$6500 and the education allowance to the institution from \$3400 to \$4000--the first increase in 8 years.

DOD initiatives in the fellowship area are applauded. We understand that the Navy has announced a plan to fund 40 appointments annually for up to three years support. These portable fellowships carry stipends of \$12,000, plus \$8000 to be paid to the institution. The awards will be highly competitive in nature. It is hoped that the Air Force and Army will also be interested in stimulating manpower development in this manner.

FIGURE 1

EXPENDITURES ON RESEARCH BUDGETS (EXCLUDING INDIRECT COSTS)
FISCAL YEARS 1970-71 THROUGH 1980-81

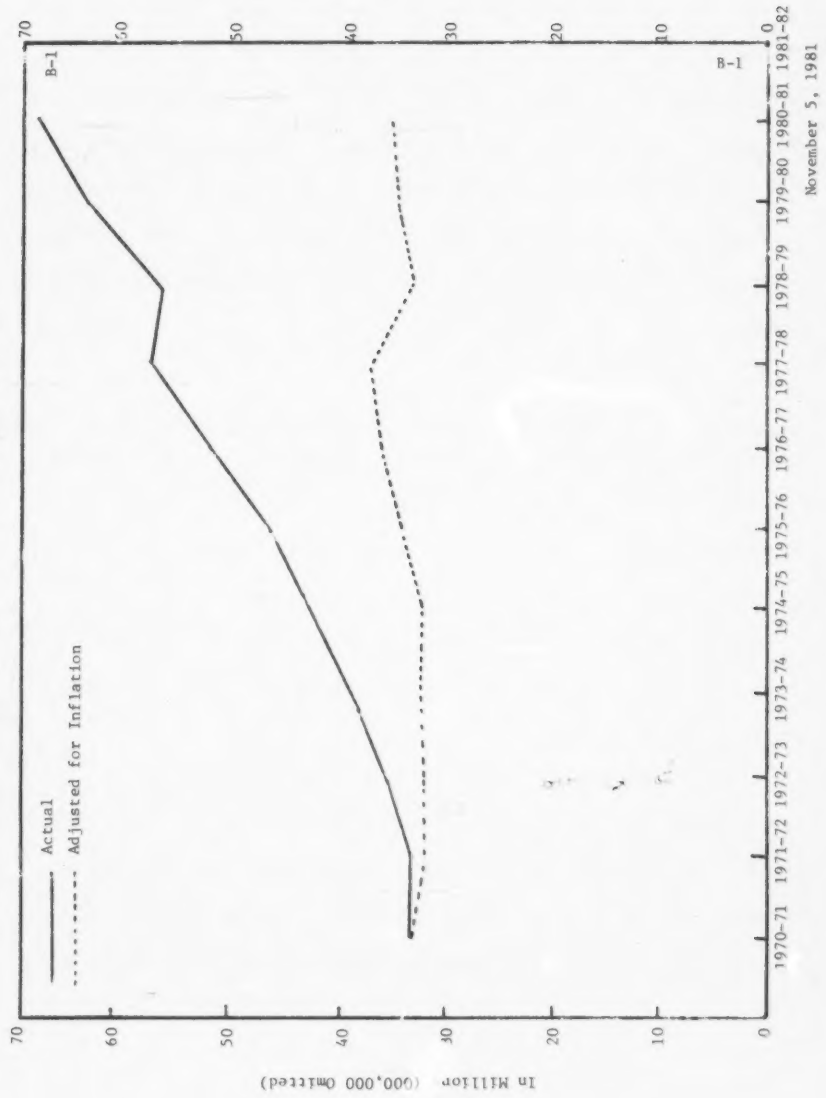


TABLE I

RESEARCH COMPETENCY

UNIVERSITY

DEPENDENT ON ON-BOARD FACULTY
SKILLS AND LABORATORY FACILITIES.
WE DO NOT RECRUIT PERSONNEL AND
BUILD FACILITIES TO UNDERTAKE
NEW RESEARCH VENTURES.

INDUSTRY

WE MAINTAIN OR ACQUIRE RESEARCH
COMPETENCIES AS NEEDED. TO ENTER
A NEW FIELD WE HIRE SKILLS OR MAY
ACQUIRE IT THROUGH ACQUISITION
OF A COMPANY ALREADY ESTABLISHED
IN THE FIELD.

39

THE TIME CYCLE OF A RESEARCH PROGRAM

UNIVERSITY

OUR ABILITY TO START A NEW PROJECT
IS AFFECTED BY THE ACADEMIC CALENDAR.
AVAILABILITY OF GRADUATE ASSISTANTS
IS ONE FACTOR. AVAILABILITY OF
FACULTY USUALLY DEPENDS ON TEACHING
RESPONSIBILITIES TERM-BY-TERM.

INDUSTRY

VERY FLEXIBLE, AND UNDER COMPANY
CONTROL, FOR START, STOP,
ACCELERATE OR PHASE OUT.

HOW RESEARCH PROGRAMS ORIGINATE

UNIVERSITY

A RESULT OF PERSONAL INTEREST ON THE PART OF A FACULTY MEMBER OR A GROUP OF FACULTY, LEADING TO A PROPOSAL TO AN OUTSIDE SPONSOR. A FEW PROJECTS RESULT FROM REQUESTS FOR PROPOSALS (RFP) FROM GOVERNMENTAL OR INDUSTRIAL SPONSORS WHICH HAPPEN TO COINCIDE WITH RESEARCH TALENTS AND INTERESTS OF ON-BOARD FACULTY.

INDUSTRY

PROJECTS ORIGINATE FROM MANY SOURCES. THESE INCLUDE CONCEPTS OF IN-HOUSE RESEARCHERS SOLD TO MANAGEMENT; MANAGEMENT DECISIONS TO MOVE INTO A NEW TECHNICAL AREA; RFP'S RECEIVED FROM GOVERNMENTAL AGENCIES OR OTHER COMPANIES. STARTING A PROGRAM IS A MANAGEMENT DECISION.

MANAGEMENT OF RESEARCH

UNIVERSITY

RESEARCH IS NOT MANAGED IN ACADEME.
THE FACULTY PRINCIPAL INVESTIGATOR
IS RESPONSIBLE FOR ADMINISTERING
THE PROJECT, MEETING SPONSOR
REQUIREMENTS, BUDGET CONTROL
AND REPORTING RESULTS. (ALL
PROPOSALS TO OUTSIDE SPONSORS ARE
REVIEWED BY PSU TO ENSURE
CONFORMANCE WITH UNIVERSITY AND
SPONSOR POLICIES.)

INDUSTRY

OUR RESEARCH GENERALLY IS HIGHLY
APPLIED OR DEVELOPMENTAL IN NATURE;
BASIC RESEARCH IS RARELY UNDERTAKEN.
WE EXPECT TANGIBLE AND PROFITABLE
RESULTS WITHIN A FEW YEARS OR WE
DROP THE PROGRAM. PROGRESS IS
REVIEWED CAREFULLY BY MANAGEMENT.

TRADE SECRECYUNIVERSITY

NO - "TRADE SECRECY" IS ALIEN TO THE PURPOSES OF A UNIVERSITY. FROM A PRACTICAL STANDPOINT, WE CANNOT GUARANTEE PROTECTION OF PROPRIETARY INFORMATION TO A SPONSOR; AT BEST WE COULD OFFER A "BEST EFFORT" BY FACULTY AND GRADUATE STUDENTS.

INDUSTRY

YES - TRADE SECRETS ARE A WAY OF LIFE, PARTICULARLY IN FAST-MOVING HIGH TECHNOLOGY AREAS. EMPLOYEES WHO DIVULGE TRADE SECRETS CAN BE AND OCCASIONALLY ARE PROSECUTED.

PUBLICATION OF RESEARCH RESULTS

UNIVERSITY

YES - OUR NUMBER ONE PRIORITY.
OUR REPUTATION IS DEPENDENT ON
PUBLICATION IN REFEREED JOURNALS.

INDUSTRY

RELUCTANTLY, IF AT ALL. WE
PUBLISH ONLY AFTER MAKING SURE
THAT IT WILL NOT HELP THE
COMPETITION, I.E., DAMAGE OUR
MARKET POSITION.

PATENT PROTECTION

UNIVERSITY

A PATENT PROGRAM IS PROVIDED FOR
THREE REASONS:

1. A PROCEDURE FOR HANDLING
PATENTS IS REQUIRED BY
SPONSORS OF RESEARCH PROGRAMS---
INCLUDING ALL FEDERAL AGENCIES.
2. PATENTS ARE AN EFFECTIVE MEANS
OF TECHNOLOGY TRANSFER, I.E.,
MOVING IDEAS FROM THE BENCH
TO THE PUBLIC SECTOR TO BENEFIT
SOCIETY.
3. PATENTS ARE A TANGIBLE RECOGNITION
OF FACULTY CREATIVITY--AND
(OCCASIONALLY) THEY FINANCIALLY
REWARD FACULTY.

POLICY: WE EXPECT TO TAKE TITLE TO ALL
PATENTS RESULTING FROM RESEARCH.

INDUSTRY

WE MAY OR MAY NOT PATENT A NEW
DEVELOPMENT. IN HIGHLY COMPETITIVE
AREAS WE OFTEN RELY ON TRADE
SECRECY AS A MEANS OF GETTING A
NEW PRODUCT TO MARKET AHEAD OF
THE COMPETITION. A PATENT IS A
PUBLICATION--WHICH MAKES IT EASIER
FOR THE COMPETITION TO COUNTER THE
ADVANCE.

POLICY: IN SPONSORING RESEARCH AT A
UNIVERSITY, WE EXPECT TO SECURE
PATENT RIGHTS.

**THE NATION'S DETERIORATING UNIVERSITY
RESEARCH FACILITIES**

**A Survey of Recent Expenditures and Projected Needs in
Fifteen Universities**

July 1981

**Association of American Universities
One Dupont Circle, N.W.
Washington, D.C. 20036**

EXECUTIVE SUMMARYOBJECTIVES
OF THE SURVEY

This survey of 15 leading universities had three objectives:

-- In the institutions surveyed, document expenditures for research facilities and major (\$100,000 or more) equipment, without regard to source of funds, over the last four years in the following six fields:

- Biological Sciences
- Chemical Sciences
- Earth Sciences
- Engineering
- Physics
- Medical Schools (10)

-- Provide responsible estimates, prepared by those universities, of expenditures for research facilities and major equipment that would be required over the next 3 years to meet the research and training needs of only current faculty.

-- From researchers and department heads, acquire assessments of the major consequences for science, industry, and government if the accumulating facilities needs of their institutions are not addressed.

FINDINGS

In many of the science and engineering departments surveyed, a substantial backlog of research facilities and equipment needs is accumulating. Projected funding needs over the next three years equal almost twice the level of expenditures by universities for their research laboratories and equipment over the past four years. Already, institutions often are unable to provide their basic science and engineering researchers and students with either the modern laboratories or equipment needed to conduct state-of-the-art research and education programs.

The loss of federal contributions to the support of research facilities and the absence of compensatory sources of support has forced many institutions to renovate and repair only those facilities in greatest need. Even this work often is carried out in a necessarily piecemeal fashion which is uneconomical over the long term. Working under such conditions, researchers unavoidably compromise their productivity and future competitiveness.

Relatively few construction projects have been completed in recent years in a majority of the physical sciences and engineering departments surveyed. Many institutions estimate substantial needs for new laboratories, for the expanded modernization and repair of old laboratories and for modern research equipment. Details are provided in the following report and the appendices. The survey's principal findings are the following:

- In the last four years, for the six fields surveyed, fifteen leading universities together spent \$400 million from all sources for facilities and major equipment. Half of those expenditures was for a relatively small number of new construction projects; the remaining half, spread over a larger number of generally less costly funding projects, was for facility modernization, major repair and renovation, and special purpose research equipment.
- In the next three years, the 15 universities estimate they should spend almost twice as much (\$765 million) just to provide the necessary research facilities and special research equipment for current faculty only. These estimates are in current dollars and, therefore, do not include the added effects of inflation.
- New construction to replace outmoded facilities accounts for almost 60% of total projected funding requirements across all fields.
- In addition, substantial needs for major research equipment were identified in all six fields. These equipment estimates include only major items costing at least \$100,000. As the 1980 AAU report to the National Science Foundation found, most departments also have serious deficiencies of less costly analytical instrumentation and support equipment.

RECOMMENDATIONS

The problems of obsolescence in the nation's university research facilities have been growing for more than a decade. To solve them, a new national investment strategy is needed. That strategy should provide direct, balanced support for university facilities from federal agencies and provide investment incentives designed to involve industry, the states, and the universities in a coordinated effort. The following steps are suggested as starting points:

1. Key Executive agencies should develop a mechanism to periodically assess the condition of university research laboratories and the consequences for the nation of that condition. Such assessments should involve the Office of

Science and Technology Policy, the National Science Foundation, the Department of Defense, the Department of Energy, the Department of Health and Human Services, the Department of Agriculture and the National Aeronautics and Space Administration. The views of industry and the universities also should be solicited.

If the initial review corroborates the assessment of this survey the following recommendations should be considered:

2. The facilities and equipment program earlier proposed to be undertaken by the National Science Foundation but deferred should be restored as a priority initiative in FY 1983.
3. The Department of Defense, Department of Energy, the National Aeronautics and Space Administration, the Department of Health and Human Services, and the Department of Agriculture should establish research instrumentation and facilities rehabilitation programs targeted on the fields of science and engineering of primary significance to their missions. The National Science Foundation should assist in the development, implementation, and coordination of those activities.
4. Incentives should be provided to encourage industries and the states to join with universities and the federal government in renewing the nation's university research laboratories.
5. Interest costs incurred in the construction, modernization, renovation, and repair of facilities in which federally supported research programs are carried out should be allowable indirect costs under OMB Circular A-21.

Mr. ERTEL. Thank you very much, Dr Cunningham, for a very comprehensive statement. I must admit it is rather provocative in some aspects, and I am sure we are going to have a lot of questions concerning it. I see some areas that I wanted to stop you and ask you about, so we will come back and certainly ask those questions.

Our next witness is Dr. Bernard P. Sagik, who is the vice president for academic affairs at Drexel University. We are looking forward to having your statement. Dr. Sagik.

Dr. SAGIK. Thank you, Mr. Chairman, members of the subcommittee and staff. I'm speaking for Drexel University, a private, technologically oriented institution, and I speak from a perspective not too dissimilar from that of my predecessor in the panel, in that I have spent half of the nearly 30 years of my postdoctoral experience in industry and the rest in the academic world.

I would like to stress the peculiar quality—if you will—the unique quality of Drexel undergraduate education. Drexel has pioneered in cooperative education for over 60 years. In all disciplines, our 7,000 undergraduates will spend from 3 to 7 quarters working away from campus after their freshman year. There are over 1,400 employing companies and agencies involved in this effort. And a plug for us—I would like to note that it was a Drexel co-op student on duty at JPL when they began transmitting from Voyager I those newly discovered 13th and 14th moons of Saturn.

Ninety-five percent of Drexel's undergraduates after the freshman year earn more than \$20 million annually toward their own cost of education. Literally, this is larger than the amount we provide internally through various Federal programs and our own moneys for student financial aid. Thus, given some financial aid in their first 18 months, Drexel students become major financial contributors to the educational process thereafter.

The importance of this can be seen in the family income analysis, which I will not go through, but which I have included.

The co-op education requirement in science and in engineering at Drexel obviously is attractive financially in an inflation-ridden economy. It has become even more so, as student financial aid packages have become uncertain or more costly. And we see this reflected in a markedly increased flow of applications to Drexel, even as demographic projections for the area suggest that enrollments ought to have peaked. Indeed at the moment, undergraduate engineering enrollments at Drexel represent close to 13 percent of all undergraduate engineering enrollments, private and public, in Pennsylvania.

Now, a second point I would like to make about our undergraduate programs is that of applications for the fall of 1982 freshman class, and this I think confirms what my colleagues here have noted: 25 percent of the total are in the two curricula which lead to the bachelor of science in electrical and computer engineering and the bachelor of science in mathematics and computer science. These applicants are predominantly from southeastern Pennsylvania, with 72 percent from Philadelphia County and the four proximate counties, and the remainder largely from New Jersey, Delaware, and the rest of the State. Only about 2 percent of these students are foreign nationals.

This unusually high concentration of regional and local students reflects the impact of cooperative education and its obvious dependence on the presence of the Delaware Valley industrial complex for job placements during the cooperative rotations. This mutually beneficial association is threatened, however, during a recession and by any growing industrial plant obsolescence which reduces the area industry's ability to compete profitably, as well as to support programs of cooperative education. So that plant obsolescence, plant deterioration, deferred upgrading is as much a problem for us if it is industrial, as if it were academic.

I would like to mention very briefly in this context of industrial cooperation, a growing need for programs of faculty renewal and faculty retraining. And it is something that I heard Dr. Cunningham refer to. That is, we learn in many areas or in some areas from industry more than they learn from us. While it is difficult to measure effectiveness precisely, our own experience with industrial leaves suggests that this device can be one means of benefiting university faculties in areas as divergent as accounting and engineering. We think the experience is beneficial to the host corporation, which may be facing some personnel freezes as well. We already utilize as adjuncts many persons employed professionally outside the university. Again, I would like to note that at Drexel, we have right now the only accredited degree program in architecture in the United States staffed wholly by adjuncts. It is a unique program and it is an attempt to bring practice to the university; the practitioner interacting with the university student. We believe inducements to facilitate increased exchanges with industry should be considered. Federal support of regional registries of industrial and university personnel willing to take part in such exchanges would be useful. These could take the form of contributions to continuing faculty benefits, which are a direct cost to the university, which at an inflationary time are almost impossible for us to maintain.

At the graduate level, the picture changes. Our applicant pool of engineering and science broadens geographically. Only 40 percent are from Pennsylvania. And, again, as other schools have noted, we have many foreign nationals applying—about 22 percent.

The number of graduate applicants at Drexel is up markedly in electrical and computer engineering, mechanical engineering, chemical engineering, materials engineering, and in physics. We are absolutely hampered in our ability to accept many fine applicants, U.S. national and foreign, both by the numbers of assistantships we can provide and by limits of space and equipment.

During the past 3 years, Drexel's engineering faculty has been awarded about \$6.9 million in Federal grants and contracts and \$1.4 million in industrial research support. The science faculty in this same period has garnered \$5.3 million in Federal aid and \$0.4 million in industrial support. Quite bluntly, we are uncertain that our faculty, despite increased research productivity, despite added recruitment, will be as successful in gaining such much needed support this fiscal year.

As has been noted by others, less than 15 percent of current Federal research and development funds is in support of basic scientific and engineering research. In the proposed modified fiscal year

1981, only DOD's budget was increased. For basic research, the proposed reduction in constant 1980 dollars is about 11 percent.

At Drexel, this growing emphasis on applied defense research is shown by the fact that in the first 3 months of the university's current fiscal year, applied research has been funded by DOD-related agencies at a rate nearly 50 percent greater than in our last fiscal year, while nondefense and basic research funding is off as is support for education in science and engineering.

We find ourselves grateful for the initiative of Dr. Slaughter in seeking cooperation between his agency and private foundations. If science-engineering education is not to be left with obsolescent equipment to use in preparing the next generation of engineers and scientists, the success of such efforts is imperative.

This year, Drexel spent of its own moneys, about three-quarters of a million dollars just to provide interactive computational capabilities for its freshmen. We need to spend at least this much to upgrade undergraduate computational capabilities each year for the foreseeable future in computer-aided design, robotics, computer graphics, systems design, and control processes.

We now provide direct university research support via faculty leaves, release time, faculty research awards, internally funded minigrants to new faculty, graduate assistantships, and equipment grants. We have increased library support for periodicals and monographs 15 percent in each of the last 3 budget years, while inflation has gone up 17 percent in this particular area in each of those 3 years, forcing us to curtail and discontinue periodical purchases.

As a private institution dedicated to cooperative education and with somewhat of a tradition of self-help to maintain, we confess that the effects of inflation and reduced support for basic engineering and science research and education are providing a real test of our ingenuity and creativity. We are happy to keep on with that self-imposed task, but are concerned that in the time of ever more limited Federal support, what moneys there are will go to a very few largely graduate institutions. Thus, the very important role of institutions such as Drexel in preparing the bulk of its students for continued study at such graduate research centers will be ignored. In the decade to come, if our teaching laboratories have antiquated and obsolete equipment, if our faculty are not permitted to compete for basic research grants, the great research universities will suffer. The graduate centers of the United States are utilizing the research potential developed in students by universities such as Drexel and this human capital is not being replenished.

Drexel research and materials engineering developed a splendid source of faculty in powder metallurgy at universities and of engineers in industries throughout the United States. Without such research and the support necessary to sustain it, from freshman year through the Ph. D., this State cannot hope to reindustrialize and this Nation must yield technological leadership to other nations in an ever-increasing number of fields.

Thank you for the privilege of speaking to you.

[The prepared statement of Dr. Sagik follows:]

Testimony of Bernard P. Sagik
Vice President for Academic Affairs
Drexel University
Philadelphia, PA 19104

Mr. Chairman, Members of the Subcommittee and Staff:

We at Drexel University are honored and grateful at being invited to present testimony on the possible effects of the proposed Federal budget on institutions of higher education, and more particularly, on Drexel University.

Drexel University is a private, non-sectarian, co-educational technologically-oriented institution which since its founding in 1891, has stressed "sound training in practical fields" ... seeking to ... "open the way to happiness through usefulness ..." As a means of achieving these goals, Drexel has pioneered in cooperative education for over 60 years. In all disciplines, our 7,000 day undergraduates spend from three to seven quarters working away from campus after their freshman year. Over 1400 employing companies and agencies are involved in this effort. (It was a Drexel co-op student who was at JPL when Voyager I transmitted pictures of the newly discovered 13th and 14th moons of Saturn.) Ninety-five percent of Drexel's undergraduates, after the freshman year, earn more than \$20,000,000 annually towards their own cost of education. This supplements the University-administered \$15,700,000. Thus, given some financial aid in their first year-and-a-half, Drexel's students become major financial contributors to the educational process thereafter. The importance of this fact is underlined by a family income analysis showing about 75% of our students to come from families whose annual income is less than \$24,000 and 90% from families with less than \$30,000 annual income (see Table).

<u>FAMILY INCOME</u>	<u># OF STUDENT APPLICANTS</u>
0 - 2,999	406
3,000 - 5,999	259
6,000 - 8,999	254
9,000 - 11,999	326
12,000 - 14,999	314
15,000 - 17,999	334
18,000 - 20,999	406
21,000 - 23,999	404
24,000 - 26,999	329
27,000 - 29,999	215
30,000 AND ABOVE	<u>348</u>
	3595

The cooperative education requirement in science and in engineering at Drexel obviously is attractive financially in an inflation-ridden economy. It is even more so as student financial aid packages become uncertain or more costly as a result of changing budgetary philosophies. We see this reflected in an increased flow of applications to Drexel even as demographic projections suggest that college enrollments in this area ought to have peaked. Indeed, undergraduate engineering enrollments at Drexel are greater than at any other private institution in Pennsylvania, representing close to 13% of all undergraduate engineering enrollments -- private and public -- in Pennsylvania.

Of applications for the Fall 1982 freshman class, 25% of the University's total are in the two curricula leading to the B.S. in Electrical and Computer Engineering and the B.S. in Mathematics and Computer Science. These applicants are predominantly from SE Pennsylvania (72% from Philadelphia County and the four proximate counties) with a large portion of the engineering students coming from New Jersey, Delaware and the rest of the State of Pennsylvania. About 2.0%

of our science and engineering undergraduates are foreign nationals. In large measure, this unusually high concentration of regional and local students reflects the impact of cooperative education and its dependence on the Delaware Valley industrial complex for job placement during cooperative rotations. This mutually beneficial association is threatened during recessionary periods and by any growing industrial plant obsolescence which reduces area industry's ability to compete profitably and to support programs of cooperative education.

I wish to address, too, in this context of industrial cooperation, the growing need for programs of faculty renewal and retraining. This is becoming an increasing area of concern as nationally the number of US graduate student applications in science and engineering peaks and the faculty, no longer increasing in number, ages along with the rest of the population. While it is difficult to measure effectiveness precisely, our own experience with industrial leaves suggests that this device can be one means of benefitting university faculties in areas as divergent as accounting and engineering. Concomitantly, the experience is beneficial to the host corporation which also may be facing personnel freezes. We already utilize as adjuncts many persons employed professionally outside the University. (Parenthetically, I note that Drexel has the only accredited degree program in Architecture in the U.S. staffed wholly by adjuncts.) Inducements to facilitate increased exchanges with industry could include (1) Federal support of regional registries of industrial and university personnel in the program, and (2) contributions to continuing faculty benefits (a direct cost to the universities, which at Drexel equals about 20% of salary).

At the graduate level, our applicant pool of engineering and science broadens geographically. Only 40% are from Pennsylvania. About 22% are foreign nationals. Again, the number of graduate applicants is up markedly at this time, in Electrical and Computer Engineering, Mechanical Engineering, Chemical Engineering, Materials Engineering, Physics. We are hampered in our ability to accept many fine applicants both by the numbers of assistantships we can provide and by the limits of space and equipment.

During the past three years, Drexel's engineering faculty has been awarded about \$6.9 million dollars in federal grants and contracts and \$1.4 million dollars in industrial research support. The science faculty in this same period has garnered \$5.3 million dollars in federal and \$.4 million dollars in industrial support. Quite bluntly, we are uncertain that our faculty, despite increased research productivity and despite added recruitment, will be as successful in gaining such much needed support this fiscal year. As has been noted by others less than 15% of current federal research and development funds is in support of basic scientific and engineering research. Our own records (noted above), confirm the major role of the federal government in supporting such research contrast the ratios of federal to industrial dollars.

In the proposed modified FY 1982 budget, only DOD's budget was increased. For basic research, the proposed reduction in constant 1980 dollars is about 11%. At Drexel, this growing emphasis on applied defense research is shown by the fact that in the first three months of the University's current fiscal year, applied research has been funded by DOD-related agencies at a rate nearly 50% greater than in our last fiscal year, while non-defense, basic research funding is off as is support for education in science and engineering.

We find ourselves grateful for the initiative of Dr. Slaughter, NSF's Director, in seeking cooperation between his agency and private foundations. If science-engineering education is not to be left with obsolescent equipment to use in preparing the next generation of engineers and scientists, the success of such efforts as Dr. Slaughter's is imperative. This year, Drexel University spent nearly \$750,000 to provide interactive computational capabilities for its freshmen. We need to spend at least this much to upgrade undergraduate computational capabilities each year for the foreseeable future in computer-aided design, robotics, computer graphics, systems design, and control processes.

We now provide direct University research support via faculty leaves, release time, faculty research awards, mini-grants to new faculty, graduate assistantships, and equipment grants. We have increased library support for periodicals and monographs 15% in each of the last three budget years (but inflation in this area has been 17%, forcing us to cancel some journals).

As a private institution dedicated to cooperative education and with a tradition of self-help to maintain, we confess that the effects of inflation and reduced support for basic engineering and science research and education are providing a veritable test of our ingenuity and creativity in utilizing space, equipment, and money. We are happy to keep on with that self-set task, but are concerned that in a time of ever more limited federal support, what monies there are will go to a few largely graduate institutions. Thus the major role of institutions such as Drexel in preparing the bulk of the students for continued study at such graduate research centers will be ignored. In the decade to come, if our teaching laboratories have antiquated and obsolete equipment, if our faculty are not permitted to compete for basic research funds, then the great research universities will suffer. The graduate centers of the U.S. are utilizing the research potential developed in students by universities such as Drexel. This human capital is not being replenished.

Drexel research in materials engineering developed a splendid source of faculty in powder metallurgy at universities and of engineers in industries throughout the U.S. Without such research and the support necessary to sustain it (from freshmen year to the Ph.D.), this State cannot hope to reindustrialize and this nation must yield technological leadership to other nations in an ever-increasing number of fields.

Thank you for the privilege of addressing you.

Mr ERTEL. Thank you very much for your outline and your very interesting testimony. I am sure that there will be a lot of questions of all of you.

I want to ask one broad question before we begin specific questioning. Recently, I heard an economist, noted as a maverick who I thought had a very interesting point. His point was that a continued reduction on the moneys provided to science education and science fields from the Federal Government together with an increase in the defense budget would cause several things to happen. First, what we would see would be a dislocation of scientific talent in this country. That, in fact, it will become less attractive to be in the universities and the colleges, as many of you have already pointed out. The climate in the industrial sector would be better because the instrumentation would be better, and the laboratory facilities would be better. Therefore, you would be moving people away from academia.

Second, because the money was going into DOD, the Defense Department, they would continue to bid up the price of scientific personnel, because the defense industry is really a high tech industry today. Most of its endeavors are in lasers or other type of high technology utilization. Therefore, there would be even more dislocation because not only will we be cutting in the one area, but there will be an increased demand for scientific personnel in the defense industry. We will be slanting more and more of our science education toward those particular high tech industries in the Defense Department, and in the long run we will hurt our science effort across the board and also our science effort in industrial competition with other countries. Therefore, we are going to have a long-term effect on our science community, and on our Nation as a whole, as a result of this slant of the Federal budget.

What is your view? No. 1, is he correct in his analysis? No. 2, if he is correct, how do we tend to ameliorate the effects of what we're doing so that we will keep an academic community, an academic atmosphere, keep basic research and also be able to compete with industry in other countries of the world? It's a pretty broad question. I would be happy to have any of your comments on it, if you would like to try and address it.

Dr. Maxwell, do you want to start, since you led off this morning?

Dr. MAXWELL. There perhaps is a certain amount of truth in that, in that if those high tech areas that are very, very narrow and applications-oriented bid up the market, so to speak, they will have a tendency to divert the educational function away from universities and toward those specific, high focused areas. I think in the long run, it is going to work to the disadvantage of science and engineering education, because it would divert some of the education function away from the universities and colleges. I think the Nation in the long run is going to be the loser because of the nature of scientific and engineering education that occurs in the universities in this State, as well as across the country, that is not biased to a particular application, whether it be to the Defense Department or to the communications industry or any other industry that has great emphasis on a particular area of technology.

I think it is important to maintain the neutrality, if you will, of science and engineering education as it occurs now in universities, because the students are benefiting from a broad range of topics, not only in the sciences, mathematics and engineering, but in the social sciences and humanities as well. The end result is an engineer or a scientist who is broadly educated.

So going back to the original question, perhaps there is a certain amount of truth that if more and more of the money is coming from high technology areas, there will be a tendency to divert education away from the institutions and toward those very specific applications-oriented industries. In the long run, I think, the Nation is going to suffer.

Mr. ERTEL. What do you suggest we do if that analysis is correct? How do we balance, if you will, our education needs in this country with the needs of industry? How do we change that dislocation, if it is going to happen?

Dr. MAXWELL. It is a matter, I think, of focusing on the preservation of undergraduate education in the way we are operating now and have for a number of years. Whether it is done as a result of Government incentives or accommodation of industry, coupled with education, it seems to me that the focus has to be on preserving and strengthening the basic undergraduate education that occurs in our institutions. If the Nation has that broad base of engineering and science talent that is not biased one way or the other, presumably, we can grow and we can continue to provide personnel for high tech areas which can then focus their continuing education in the areas that are of greatest benefit to them.

So I think the answer to your second question is to continue to improve and to support the basic undergraduate educational process, whether it be in science or in engineering.

Mr. ERTEL. I appreciate your point of view that you alluded to in your testimony on page 5. That is, the need to support the instructional scientific equipment program, local course improvement program, undergraduate research participation program, and the Comprehensive Assistance for Undergraduate Science Education (CAUSE) program. It is my understanding that all of those have been zeroed out, while these are programs which would do the balancing you are talking about.

Dr. MAXWELL. That is right.

Mr. ERTEL. So I think the bottom line of what you are saying is that we are looking down the road to a real dislocation, unless we start changing total priorities in our science community.

Dr. MAXWELL. That is right.

Mr. ERTEL. Would that be a fair analysis?

Dr. MAXWELL. I think that's a fair analysis. Those programs you just mentioned that I had in my document, are all programs that are focused on undergraduate education, whether it is course improvement, program development, equipment acquisition, or equipment replacement. The focus is clearly at the undergraduate level. And it is also my understanding that these programs have been zeroed out at the present time.

For institutions like Bucknell, that focus at the undergraduate level, the loss of these funds has been critical. Some of the funds can be made up through internal funds of institutions, but that is a

partial replacement and a short term replacement, at best. Some of the slack can be taken up by industry. But, again, the emphasis there is often to the very focused and applications-oriented aspect of that particular industry.

Mr. ERTEL. That brings me to the next question that I was going to ask, particularly since Dr. Cunningham alluded to it. In your testimony, Dr. Cunningham, you said that you recommended tax incentives to really try to solve some of the problems we have been addressing. I have some questions about that because tax incentives imply that we allow the private sector to set the priorities. That is, tax incentives are targeted in the sense that a particular industry wants research done in only specific areas, those which are relevant to its own corporate goals. Therefore you're going to have gaps, it seems to me. This is my own personal view. There will be gaps because you are going to find some areas in which people are very much interested in as a company, as a corporate entity, but there will be other areas of equal fundamental importance in which no one is really concerned.

So I wonder if tax incentives are going to be the answer. In addition, tax incentives are Federal moneys. We will therefore be subsidizing special interests with Federal dollars. Furthermore, the priorities would not necessarily be national priorities, but would be set by the private sector.

What would be your response to that? And is that correct?

Dr. CUNNINGHAM. The expression "tax expenditure," which I believe you are using is something that has bothered me for a long time. I find it difficult to see a tax incentive as a Government gift. I prefer to look at it as not taking money from the taxpayer in the first place.

Mr. ERTEL. May I respond to that for a moment?

Dr. CUNNINGHAM. Yes, sir.

Mr. ERTEL. Because I am interested in that concept. If we, in fact have a tax program, and everybody is expected to pay those taxes, and then we make a special exception for somebody, we have really set some sort of priority by having a kind of specialized tax relief, if you will.

Maybe the word expenditure wouldn't be correct, but at least we are setting a priority within a broad range, and then that priority becomes much more specialized with that individual who gets that very specialized tax relief.

Dr. CUNNINGHAM. The reason or rationale for the recommendation for tax incentives flows from the pronounced differences between the usual research in an academic setting and what is wanted by industry. To be quite frank, most industry does not need university research contributions. If the country wants to encourage this coupling of universities and industry, a positive push in that direction is needed. And while I certainly cannot prove it in dollars, it may be quite effective in terms of net cost to the Government to encourage greater coupling between industry and universities, than to try and do it all out of Washington, which has been the case for the last 30 years.

Studies of the relative cost effectiveness of these two approaches might be a very interesting study.

I would like to come back to your initial question about the Department of Defense, and if possible, its unfortunate impact on academe. I would like to suggest two things. First of all, in our experience at the university, the DOD's track record in supporting research has been far better than a more recent agency, the Department of Energy.

The Mansfield amendment, many years back, was very unfortunate. It prohibited the Department of Defense from funding research, except that which applied to an immediate product need in the Department of Defense. We hope that the Mansfield amendment is disappearing.

My response to your question is that we certainly should not limit DOD support or discourage it. It will focus on high technology in which this country is falling behind. Note that the graduate-level manpower training is a valuable byproduct of DOD research sponsorship in academic.

I think that DOD has done a good job in supporting university research. I might point out, and I am sure you know this already Mr. Ertel, that the National Science Foundation's approach to support of research, is a result of the Navy's ONR in World War II. They knew what they were doing then, and by and large, they do a pretty good job now.

Mr. ERTEL. Did you have any comments on that question?

Dr. SAGIK. At the risk of delaying anyone from stretching, I would like to make a couple of comments, if I may.

Mr. ERTEL. I will defer to your comments.

Dr. SAGIK. One of them is that I don't think there is such a thing as a neutral direction grant, or contract. DOD will push in certain directions for its needs. The National Cancer Institute pushed biology into a particular direction for 20 years, which may not have been, in hindsight and retrospectively, as fruitful as any 1 of 10 other directions that could have been taken.

I think we have had some recent experience with industry which encourages me, in that a large corporation, in this case Martin-Marietta recognized the need for certain types of basic information which could be developed at a university. They did not want to do it in-house. They gave us grants in areas as divergent as laser optics and psychrophilic fungi—that is, fungi which thrive in the cold—things you don't usually associate with Martin-Marietta. I believe that whether you call it tax incentive or a diversion of tax money or tax expenditures, there are certain benefits which obviously such corporations have recognized accrue to them by support of this type of research. And so I do believe that with some support from the Government in one form or another, and industrial support, we could probably manage to come through the next decade—decade and a half. But if we are left solely to DOD and what industry leaves for us, and we lose the support of NSF, and we got back at NIH, I see some very severe problems.

Mr. ERTEL. Thank you very much. Congressman Shamansky.

Mr. SHAMANSKY. Thank you, Mr. Chairman. Dr. Cunningham, on page 2 of your testimony, you had a line that caught my attention, because I have a great deal of trouble squaring it with what followed in your testimony, and that of the other gentlemen who testified.

You say there "I wholeheartedly support Government efforts to get inflation under control." I cannot think of anybody who would challenge that statement as such.

The problem is that it seems that you gentlemen have been defining and pointing out what those efforts of the current administration are leading them to do to get inflation under control, that is, to stop Government expenditures.

Now, I don't mind telling you that I don't fully understand, without apology, what supply-side economics is. No one has yet quite defined it clearly for me. But I do know that the policies followed by this administration are leading to a decrease in the number of engineers. I know that is the direct opposite of increasing the supply.

So the problem arises for me, and I would like to have your insight. What do you think in your position, is it any Government efforts to get inflation under control and, are you and your colleagues addressing the administration on these things? We hope to provide you with a platform to inform us. I am just curious as to what your professional organizations, and you have a splendid list of them who have endorsed your comments, are doing specifically with the policy formulators, namely the executive branch, to get some turnaround in this thing? Because I see the things you have presented being wiped out, zero instrumentation, zero science education. What are you doing in that area with the splendid list of organizations, whom you are representing?

Dr. CUNNINGHAM. There is a parallel perhaps between what the Pennsylvania State University has had to do to cope with inflation and what the Federal Government is having to do. It is much easier to mount new programs, spend new money, than it is to curtail programs. We have discovered that painfully year by year in budget hearings for the last 5 years. But hard choices must be made and one moves money from less essential programs to those more essential.

I think that the best service that universities, usually through these associations, can provide to the Congress and the executive branch, is to provide information on the consequences of cuts in various areas, and to identify those most damaging in the long run.

It is unacceptable to me for universities to dig in their heels and say, "You cannot cut one nickel from education expenditures; do the cutting every place else but leave us alone." Obviously, this will fall on deaf ears. My comment ties directly with that 10-year curve of funny-money inflated dollars versus constant 1971 dollars. We suffer from it. We do not like it and we see that inflation must be brought under control or some better degree of control.

Mr. SHAMANSKY. Then let me just refocus slightly. The administration is cutting back on instrumentation and science and engineering education, which leads to fewer and fewer graduates in the area that we want them. This is done in the name of budget cutting. It seems to me a lack of discrimination or intelligence in making these judgments. And I am concerned that we accept everything under the rubric, "Well, we are saving money." You know, we end up shooting ourselves in the foot, in these very areas that you are talking about.

Dr. CUNNINGHAM. No. Let me say, again, that I think that higher education has the responsibility to report on the impacts of

these effects and to do that, rather than simply saying do not cut at all. And I must say that I do not think the associations, to my knowledge, have done a very good job of that. They have a tendency to say, do not make any cuts whatsoever.

Mr. SHAMANSKY. I have one last comment. We have to go on and get to the other panel. Our committee, the Committee of Science and Technology, voted not to fund the Clinch River breeder reactor. We have excellent testimony that says it is simply obsolete already. So it should not be funded—it gets about \$240 million, which just overwhelms the numbers that you are talking about here. It is simply incredible and it is in there for the grossest political payoff purpose. And I would hope that your associations would object mightily to that kind of misallocation of resources. Thank you, Mr. Chairman.

Mr. ERTEL. Thank you, Mr. Shamansky. Chairman Walgren.

Mr. WALGREN. I wanted just to ask whether or not the members of this panel would individually support across-the-board budget cuts in these areas? No.

[Nods in response.]

Mr. ERTEL. I am sorry. Your head shakes do not appear on the record. We have to have an answer.

Dr. CUNNINGHAM. My answer is no. I think we have long passed that point. The sure way to mediocrity is to shave evenly and let all programs wind down. We have to strengthen good programs and discontinue weak programs.

Dr. MAXWELL. I would agree with the same comments. It seems to me that priorities have to be established and cuts, differential cuts made accordingly.

Dr. SAGIK. There is no question in my mind that in eliminating all of science education, we eliminated several programs which were not genuinely fruitful, but we eliminated the most powerful tool for improvement this country has had.

Mr. WALGREN. Well, I think that is an important message. These hearings are important in that we can both get your opinions and inform the public of what is happening in Washington. And this is an area, in particular, where the cuts have been meted out quite across-the-board.

The thing that concerns me most is that the administration's approach has been one that did not respect the Congress ability to differentiate and to be more sensitive to some areas and less sensitive in other areas. My own view is that when you turn to OMB, is that you have no more people than can fit around that table deciding the detailed budget appropriations for the whole Nation's economy as a whole.

And no matter how bright the people that sit around that table are, or how facile they are with the numbers, they cannot have the breadth of sensitivity that is necessary to strike the constructive balances that have to be struck. And I think that we ought to realize what has gone on in Washington, particularly in the science area. The testimony before our committee showed that the line items, the zeroing out of these particular programs, were decided on by the administration, and presented to the National Science Foundation with less than 24 hours to respond.

And the truth of it is that when you step back and look at those things, you see a political agenda in the distribution of the cuts by the administration, a political agenda of a very small number of people. As one critic has said, the administration is "taking the ship out of New York Harbor and turning north to Miami." I hope that we can understand that one of the reasons for this is that they have turned away congressional input and ignored congressional sensitivity.

I feel that in an area where there is a very basic national interest, that we cannot afford to make that kind of mistake. I would hope that the interest groups involved will speak to the public on this point, because as long as we are sort of anesthetized by the mood of the country, we will not make the changes that are necessary.

I noticed in an article in one of the magazines, that they were asking how the budget cut play in Peoria? And, well, the truth of it is, across-the-board budget cuts played very well in Peoria. The reason, according to the mayor of Peoria, that to suggest that we should not cut these budgets when efforts are being made to expand private research is premature.

Well, I think the testimony we get is, that private research is limited. Therefore, there must be special programs that fill in around private research. And your answer to me that none of you support across-the-board budget cuts is something I think that ought to go back to the administration, so that even though it might play in Peoria, we know that we are jeopardizing the national interest by taking that approach.

I am sorry for more of a statement than a question, but I appreciate the opportunity to get that off my chest.

Mr. ERTEL. Thank you Congressman Walgren. I guess we all come at these particular areas with a particular perspective. It depends to a great degree on what we look for as a nation and where we think we ought to be going.

In a recent article, the new science advisor—incidentally, when many of these things were being decided, there was no science advisor to the President. But the new science advisor, George Keyworth, made the comment in talking about the current science education program, and I quote "The programs were ineffective." And he was for cutting them all out.

Do you agree with that kind of a statement, that they are all ineffective?

Dr. MAXWELL. Absolutely not. I can go back to what we have been doing at Bucknell during the last year. Last summer, within the chemistry department, we had 35 students participating in undergraduate research activities with faculty members at the undergraduate level, and that program was made possible by the undergraduate research program of NSF. The instructional scientific equipment program is a program which has provided for Bucknell, and I am sure every school can make the same comment, valuable and much needed equipment, to try to stay at the forefront of what is occurring in computer science or electrical engineering or materials.

The comprehensive assistance to undergraduate scientific education programs is a programs which provides up to \$250,000 on a 3-

year basis to establish and implement new and innovative programs. These programs typically would not have occurred, had it not been for National Science Foundation funding. At Bucknell, for example, we established an environmental science program, together with an up-to-date state-of-the-art laboratory, and a two-course sequence that was made totally possible by the NSF funding.

There perhaps are some aspects of various programs, and perhaps even specific programs that are not as effective as NSF and some funding agencies would like, but on balance, it has been my observation, that good things happened at the undergraduate level as a result of those kinds of programs.

Mr. ERTEL. Would anyone else like to comment on that?

Dr. SAGIK. I think one of the more serious concerns I have is the student's perception of a career in science or engineering. In the high schools, the perception is not an attractive life in science and engineering. One of the best programs to counter this was to have high school students working with local university faculty in the laboratories. This was an NSF program. In my years at Texas, we saw students from high schools move into this program, get so enthralled by it, they did not always stay with us. They went on. They were very competitive. They went on to Princeton, to Yale, and Tulane. We became a breeding ground for first-rate students for first-rate institutions, largely through NSF support. These students are not going to have that kind of incentive, that kind of opportunity.

Mr. ERTEL. Dr. Cunningham, do you have any comments you would like to add?

Dr. CUNNINGHAM. I think the error that has been committed is tarring the entire science education program with some mediocre results, and you alluded to political viewpoints yourself.

I doubt very much that a program that has been this large and has run this long has not made some mistakes. And the corrective action that I think should be taken is a dispassionate review of what has been done, what has worked and what has not worked and to continue those areas that are demonstrably valuable.

At the risk of sounding a bit old-fashioned, I think that that type program ought to concentrate on helping teachers in junior colleges and high schools to update them, help them do a better job of teaching science and mathematics. Let's spend less money on survey courses on the understanding of science, the sociology of science et al. and help teachers upgrade science and math education in our secondary schools.

And if they would concentrate on that, I think that most of the negative reaction could be eliminated.

Mr. WALGREN. Let me ask one question. How do you view the preparation of students coming to you in the colleges at this point? It has been said that since our high schools, and even pre-high school studies, don't have an attractive science component, that these young people who come through there never even get a chance to decide to go into science because they got left off the train when initial preparation had to be made. Do you find that in your undergraduates?

Dr. SAGIK. Mathematics, sir, would you not think is the weakest point?

Dr. CUNNINGHAM. It is. We have large problems in our primary and secondary schools in teacher preparation. Not only in science, but "reading, writing and arithmetic," in general. I think it is well acknowledged that we have a problem.

Mr. ERTEL. Well, I think with that, we will move on to our next panel. I just might point out to you that both my thermodynamics and my fluid mechanics classes—in fluid mechanics I think I had 10 in a class, in thermo I think I had 5. So I am an advocate of small classes. But that is only a result of my experience, because I probably never had more than 27 in my engineering classes at all.

Thank you very much for participating, and we appreciate your testimony. We will be taking it back to Washington with us. Obviously, it has been controversial or we would not have been asking as many questions. Thank you for participating.

We have two additional witnesses in the next panel; Dr. Herman Branson, president of Lincoln University, and we appreciate your coming Dr. Branson and being with us. And Mr. Sheldon Haas, who is from the Institute of Electrical and Electronic Engineers from Philadelphia.

Dr. Branson, it is our understanding that you have not a written statement, so we will appreciate your comments and I understand you will followup and submit a written statement for the record. And we do appreciate that. Mr. Haas, we will also incorporate your written statement in the record, and you may summarize it as you wish. Dr. Branson.

STATEMENTS OF DR. HERMAN BRANSON, PRESIDENT OF LINCOLN UNIVERSITY; SHELDON HAAS, INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS

Dr. BRANSON. Thank you very much, Congressman Ertel. I come before you this morning representing the AASCU, the American Association of State Colleges and Universities, but more especially I am representing another group called NAFEOHE, the National Association For Equal Opportunity in Higher Education.

And this morning I would like to review some data with you, in order to give you, I hope, a feeling that there is absolute necessity for us to do a little focusing, whatever we do from now on, in making opportunity available for American citizens. And so my first objective, Congressman Ertel, will be to go over some data.

I would like, first, to remind you of something that a great man said a long time ago, and that is "In the conditions of the modern world, that group is doomed which does not give emphasis to trained intelligence." I think that is certainly true now as we go to the end of the 20th century.

And I would like to call your attention to an article which appeared in "The Chronicle of Higher Education," page 19, for November 11, 1981. It says "Drop in number of science students worries Israelis." Now here is a small country, and yet a drop in the number of science students is such that it gains international attention. And what was the drop? Within 7 years, there was a 25-percent lowering in the number of students going into physics and chemistry.

Now, what is the situation in America for 25 million people, 10 percent of the American population? Well, we have some of that. As we look, for example, at a profile of 1979-1980 Ph. Ds given in America, published on October 7, 1981, we found an amazing fact. We find, for example, that in engineering, the field that you are very much concerned about, while there were 2,479 doctor's degrees given, blacks in America received 18, 0.7 of 1 percent. There should be at least a fifteenfold increase in that number for any kind of parity.

We read further, in mathematics, 745 degrees were granted and there should have been more; yet blacks received twelve, 2.1 percent. In the physical sciences, there were 3,151; blacks received 29, nine-tenths of 1 percent. And that field which was just mentioned a few moments ago, an all-important field in the modern world, computer sciences, 218 doctor's degrees were given, and blacks got zero. In brief, what we are saying is that whatever is done, there is an absolute necessity for us to look carefully to see how we can make opportunity available to people it has not been available to so far.

Now, things have improved greatly. And it is due to the magnificent work, I think, of the Congress. The programs which have been available have been very good. For example, we at Lincoln have a combined engineering program with Drexel, Penn State and Lafayette. And we are very pleased that this year two of our young women, two black women received degrees in engineering, one in electrical engineering and one in chemical engineering. And that is a national event of great significance, because we do not have too many young people going into this area.

So what we are really asking is for you to focus carefully, and please do not throw out the baby with the bath water. The baby is making opportunity truly available to American citizens.

Mr. WALGREN. Could I ask you to go back and just go through those numbers again for me?

Dr. BRANSON. Yes, sir, I am delighted to. This table is going to be the report, and if you would like, I will give you my personal copy before I leave. But I will repeat them once more because they are really repellent statistics of neglect and inattention, and you should be concerned about them.

Once more, for example, in engineering there were 2,479 doctor's degrees, only 18 blacks, 0.7 percent. In mathematics, there were 745 doctor's degrees, only 12 blacks, 2.1 percent. In the physical sciences—chemistry, physics, geology—there were 3,151 doctor's degrees, blacks 29, which is nine-tenths of 1 percent. And in computer science, where there were 218 doctor's degrees, blacks zero. A very easy statistic to remember, 0 percent. Zero percent.

And so, consequently, we think that whatever is done, we must ask sincerely that some sort of differential thinking is done and we do not, for example, destroy this small beginning which we now see.

And when we look further, for example, and we feel proud and pleased that things like this are happening but everything else is going along well, the answer, of course is no. And I want to give you just a few other bits of information, in case you believe it; and I am very, very careful not, for instance, to gather anymore data

myself. In other words, I wait for the data to come out and then we pounce upon it, because the facts are really quite, quite disturbing.

Pennsylvania is a great State. Lincoln is proud. Since 1854, we have made fantastic contributions, and we are very eager to continue to do that. But when we look at the data in Pennsylvania, we find a fact which perhaps none of you know. Data coming out of Harrisburg said that in 1973-74, of the doctors' degrees given in Pennsylvania, 3.9 percent, roughly 4 percent went to blacks. That is in 1973-74.

Three years later, now what were the Israelis concerned about, there was a 25-percent drop over 7 years. Three years later, according to these data out of Harrisburg, in 1976-77, the number of doctors' degrees received by blacks in Pennsylvania was 2 percent. There was a 50-percent drop, 3.9, make it 4, from 4 percent to 2 percent over a 3-year period. But "The Chronicle of Higher Education," sir, did not have an article on that. Nobody paid any attention.

And that is a tragedy. The tragedy is that things like this go on, and unless you gentlemen have the intestinal fortitude to stand up and say something, and point out that this must not continue, then it will continue. For it is not something that benign neglect does very much about.

Mr. ERTEL. Dr. Branson, if I may interrupt you, you have given us the statistics. Now, can you give me the reason?

Dr. BRANSON. The reasons, sir, are very profound. We think one is that we do not have the necessary resources to give the encouragement to the young people; to point out to them that these are possibilities, that these are careers which they can go into; that there is need, for example, for a program such as you have in MISIP. There are reasons for the programs which you have in the National Science Foundation, which have in the past been very helpful in enabling us to do a better job here.

We have been doing a better job. For example, in the last decade at Lincoln, we have moved up in sending more and more of our young people into these areas. But it is threatened. Although, I should tell you in all honesty, the President states that he will not hurt the predominantly black colleges in America. We were scheduled to have a meeting with Mr. Bush on December 1, but it was rescheduled for after the first of the year.

Mr. SHAMANSKY. Dr. Branson, excuse me. You understand, the President also promised not to hurt social security and Head Start.

Dr. BRANSON. Well, sir, I agree. That is why I said promised, sir. But what I am really frightened over is just what you are frightened over, that the actual movement will be not only to decrease, but perhaps to wipe out entirely these small advances which we have made.

Mr. SHAMANSKY. Dr. Branson, why don't you just count on that.

Dr. BRANSON. Count on what, sir?

Mr. SHAMANSKY. The wiping out of these things.

Dr. BRANSON. Well, sir, that is why I am here today. I have the same problem on my campus. My students are concerned about security. But that is what happens. The unemployment figure for our students, 95-percent black, now up to about almost 17 percent. And among the young people, it is over 40 percent. And yet prices are

going up and up, and we cannot afford everything they want. But they do not know this so they say—Why can't you get more armed police on our campus? Because they cost money. And there is no source for them, unless the Federal sources or the State sources. And with both drying up, this is going to be a desperate period in American higher education for blacks, unless something is done here.

But I would like to just fortify you with more and more, just two other sets of data on this to give you a feeling that this is truly—once more, these alarming statistics of neglect and inattention. And unless something is done, we are going to have a very, very serious problem in our society in the next few years.

Another point which I would like to make on that, sir, and I have given you these other data showing just what happened in a great State like Pennsylvania and no attention was given. Let me give you some other data which really worries us at the collegiate level, and there was more talk of this in the other panel.

Here is some data showing, for example, the 11th and 12th grade figures on drop-outs in Pennsylvania. For example, in the overall figures in this particular year, the most recent I have, the overall drop from 165,000 in 11th grade to 160,000 in 11th grade. Among whites it dropped from 146,000 to 144,000, roughly a 2,000 drop. But for blacks, it dropped from 17,900 to 13,000, a 4,000 drop. Most of the this overall drop is attributable to these young black people. Therefore, there is desperate need for us to have programs where we can go into the secondary schools and convince these young people that science or engineering is a realistic aspiration for them.

The most recent data, which we saw in the New York Times yesterday, the whole question of—Why can't Johnny read? Johnny can't read because Johnny sees no reason for reading. Unless these young people feel as though there is something for them to do in this society, that there is a light at the end of this particular tunnel, they are not going to pay attention to any of this. They are going to do exactly as we are seeing. Where our major concern is go get what? To get more facilities for prisoners—Which is tragic.

And what we are saying is, that an expenditure of a few more dollars now would eliminate the need for these things down the road. But if you do not aid us, if you do not, for example, come and make a strong argument to see that these things do not happen, we are going to be in a very tragic situation.

Mr. SHAMANSKY. I guess I am going to wag the finger. Everyone has been pointing fingers at each other. You are telling us what we have to do. And I am suggesting to you, sir, you and the constituency that you represent—

Dr. BRANSON. We are working on it, sir.

Mr. SHAMANSKY. Well, you had better.

Dr. BRANSON. Oh, yes, sir.

Mr. SHAMANSKY. Because you are at the ballot box.

Dr. BRANSON. Yes, sir. We are working on it.

Mr. SHAMANSKY. And your votes at the ballot box are significantly more important, frankly, than what we are doing, in my opinion.

Dr. BRANSON. Well, I guess what I am saying, sir, is you take every opportunity you can get. Certainly, we are concerned about this. We are in close touch with the Congressional Black Caucus,

for example, on these issues. We supply them with information. We meet with them regularly.

Mr. SHAMANSKY. What do you do about the white representatives in your own area?

Dr. BRANSON. We do the same thing with them. Congressman Ertel will tell you, we just had a lunch recently with the Pennsylvania congressional delegation where we mentioned some of these things. So we keep on doing it. We talk to everyone who has any influence. We talk to our friends in the Cabinet and elsewhere.

Mr. SHAMANSKY. What do you do about your voters, is what I am getting at? The people that—

Dr. BRANSON. Well, sir, we talk to them, too. And we tell them the tragic implications, unless something is done to stop this particular movement.

Mr. ERTEL. I would have to tell Congressman Shamansky that Dr. Branson has been very vocal on his positions on these particular things, and has really been involved in an educational process, as far as Pennsylvania is concerned. And we commend him for that. I think he has been well out in front.

Mr. SHAMANSKY. Maybe he would like to come to Ohio and help.

Dr. BRANSON. Well, sir, I have a great affection for Ohio. I found my wife there. And I went to the University of Cincinnati.

Mr. ERTEL. We will not hold it against you that you went to the University of Cincinnati.

Dr. BRANSON. Well, I also went to the University of Pittsburgh, sir.

Mr. ERTEL. Then you are all right.

Dr. BRANSON. And I was for many years head of the physics department at Howard in Washington and my favorite course was engineering physics. And I had four courses in thermodynamics, ending up with one at Cal Tech under the great Paul S. Epstein. So I feel and know the things that you are talking here.

But in all sincerity, and I would like to summarize now and close, because I do not want to keep you gentlemen too long, but if you would like me to, I could almost go all day. But let me tell you one thing which really does concern us deeply.

One of the things which Lincoln has been doing since 1854, has been aiding Africans to get a background to go back. And we have been very pleased. Once upon a time we could brag that we were the only school in America who had alumni who were simultaneously heads of countries. They were Azikiwe, who was head of Nigeria, and at the same time Nkrumah was head of Ghana. Both of them were Lincoln graduates.

But now we find a big difference. In the early days, when they came to the university, they came primarily to get training in political science, so they could go back to move into government. But now what do we find?

A few years ago we gave an honorary degree to the President of Sierra Leone. He did not write us back and say "Send me someone, some brother who can give me some skin." No. What does the University of Sierra Leone want? They advertise. The University of Sierra Leone needs a senior lecturer in applied mathematics. What do they need in Mozambique? They need some experienced engineers in telecommunications, meteorological services. And Kenya,

beautiful Kenya, the finest climate in the world, what are they advertising for? Plant virologists. And we, with 25 million people, who should be sending over those who would make a difference in our international relationships, we cannot do it. Because blacks have not been encouraged in the American social scene to move into areas like this.

And so we urge you, and we certainly do everything we can in every particular forum that we can find someone to listen to us. But we think, sir, that this goes beyond just—you know here are people who can say "Well, if you cut it"—But if you cut here, it is going to be horribly tragic, not only for 25 million Americans, but for our whole posture and presentation before 300 million people in Africa, as well as other people over the world.

So with your permission, Congressman Ertel, I will stop right there. But if you have any questions which are brought up on any of these, I would be delighted to go back and emphasize.

Mr. ERTEL. Thank you very much, Dr. Branson. I think what we would like to do at this point is go on to Mr. Haas and have his testimony, and then we will come back and ask questions of both of you. Mr. Haas.

[The biographical sketch of Mr. Haas follows:]

I. SHELDON HAAS

I. Sheldon Haas is currently a senior consultant for space systems operations of the General Electric Space Division, which includes responsibilities for division technology activities, establishing new management systems for ongoing activities, and general consulting for programs such as Landsat and DSCS.

Prior to this recent assignment, Mr. Haas was General Manager, Communication Satellite Programs, with responsibilities for on going commercial and international communication satellite programs, and advanced military and commercial satellite activities.

Mr. Haas received a B.S. in Electrical Engineering (Magnum Cum Laude), from City College of New York, and his Masters Degree in Mathematics and Science at Union College, Schenectady, New York. He is a Senior Member of the IEEE, as well as a member of both AIAA and AFCEA.

Mr. HAAS. Thank you, Congressman Ertel, and members of the subcommittee. I appear before you today on behalf of the research and development committee of the Institute of Electrical and Electronics Engineers, the IEEE. The IEEE is the world's largest technical/professional society with over 165,000 U.S. members and about 60,000 members in the rest of the world, representing all disciplines of electrical and electronics engineering, and computer sciences.

In 1980, the IEEE founded its research and development committee, a mechanism through which the institute formulates and voices its concerns on Federal research and development funding and policies.

We appear before you this morning to comment on the potential impacts of the Reagan administration cutbacks in Federal research and development funding. It is difficult to do more than speculate when the Nation is only little more than 2 months into fiscal year 1982 budget, where the bulk of these cuts first appear, and the total budget for 1982 has yet to emerge from the Congress. We will, nevertheless, try to draw some inferences from the trends we have witnessed over the past year. And we take note of the discussion

that went on today in this hearing of approximately a 12-percent across-the-board cut, which included those cuts in research and development.

One of the most important issues facing the United States today is the continuing economic vitality of the Nation. It is important not only to our own citizens, but also for people throughout the world who are dependent on our technology to provide needed goods and services. We recognize the threat which inflation poses on our economic vitality, and we support measures to curb it.

We believe that technology is the key to economic vitality. Technology must be effectively utilized and advanced to provide better products and services, using labor, capital, and raw materials more efficiently than ever before.

Certainly, since World War II, the United States has been a technological leader, as it has in the past, but technological leadership is not a static condition. It requires continual attention and dedicated effort. If we fail to continue to improve and move forward, we will be challenged and overtaken in specific areas, as evidenced by the very significant Japanese and Western European competition in steel, automobiles, consumer electronics, and a variety of other products, which are continuing to grow.

The philosophy of the administration has been that the Federal Government should confine its research activities to long-term, high risk ventures, which industry is unlikely to fund. Industry, in turn, is expected to fill the gap caused by reduced Federal research as a result of tax incentives for increased R. & D. spending which accompanied the budget reductions passed earlier this year. These incentives provide for up to 25 percent writeoff for internal R. & D. expenditures which exceed a company's average R. & D. funding for the preceding 3 years. Additional incentives include tax reductions on equipment donations and contributions to nonprofit institutions.

The 25-percent writeoff for internal R. & D. expenditures exceeding a 3-year average at best makes no distinction between short-term and long-term R. & D. For example, a company only benefits from that proportion of its current R. & D. expenditures which exceed the 3-year average. Long-term R. & D. which is not expected to pay off for 3 or more years would raise the average, and would thus seem to reduce the tax advantage. As a result, one could expect that any increases in corporate R. & D. would be for short-term, product oriented and directed research. With industry focusing on short-term R. & D., much of the cuts in Federal funding for basic research will result in the termination of many important research efforts, and we heard about many of those here this morning.

For example, one area of severe cutbacks has been NASA, the National Aeronautics and Space Administration. Because of the mission needs of the U.S. space program, major advances have been made in numerous electronics technologies, including computers, communications, control and guidance, as well as remote sensing. These technological advances have been the foundations of major high technology industries which contribute substantially to our Nation's economy and trade balance.

During the development of the Space Shuttle, however, many opportunities and new initiatives have been delayed or deferred, and overall funding for the civilian space program has been severely constrained and continues to be. While the communications sector is at the forefront of commercializing many near Earth satellite technologies, many of the NASA programs being impacted by budget cuts are in basic research, such as the planetary program. There is virtually no chance of the private sector supporting such initiatives. The research gaps which result from the cutbacks in Government funding will almost certainly impact our future leadership position in space science. And if one looks at the budgets for applications in space of both Japan and European nations, we find their budgets exceeding our own.

Another problem is the need of our universities to upgrade their research facilities. Providing tax credits to industry for equipment donations to nonprofit research institutions may help the generally recognized problem of outdated university research equipment. But can such donations be relied upon to provide sufficiently meaningful research opportunities to attract more graduate students and faculty?

Another issue is whether the transition from Federal to private sector support of university research will enable the necessary continuity of programs and research teams. Providing tax credits to industry for R. & D. funding contributions to nonprofit institutions may eventually transfer some support of university research to the private sector. But will the time lag between the reduction of Federal support and the increase in private sector support cause extensive disruptions in the continuity of university research, with subsequent impacts on the quality and quantity of our graduate students and faculty?

Another approach to fostering private sector support to universities, albeit much smaller in scope, was the Stevenson-Wydler Technology Innovation Act of 1980. Under this legislation, Federal seed money would have sponsored several joint university-industrial research centers, the support for which would have eventually been taken over by industry. The administration, however, chose not to adopt this avenue, which we believe would have provided a much greater degree of stability in transferring support for research from the Government to the private sector.

Generally, then we would identify three problems with the Reagan administration's approach to research. First, reductions in Federal support for long term, basic research will almost certainly result in a loss of much of this research, because industry has no incentive to contribute to it. Second, it appears doubtful that current incentives for industry to increase support to the universities will enable the badly needed upgrading of university research facilities. Finally, even if industry is ultimately able to replace the reduction in Federal support of university research facilities, the timelag may well cause major disruptions in graduate curricula, impacting the quality of these graduate programs.

We certainly appreciate this opportunity to share our views with you this morning, and would be most happy to provide you with any further information we can in support of your deliberations.

[The prepared statement of Mr. Haas follows:]



THE INSTITUTE OF
ELECTRICAL AND
ELECTRONICS
ENGINEERS, INC.

UNITED STATES ACTIVITIES BOARD
RESEARCH AND DEVELOPMENT COMMITTEE

PLEASE REPLY TO:

Testimony of the IEEE Research and Development Committee
Before the House Science and Technology Committee
Subcommittee on Science, Research and Technology
December 14, 1981
Harrisburg, Pennsylvania

Mr. Chairman, Members of this Subcommittee, my name is Sheldon Haas, and I appear before you today on behalf of the Research and Development Committee of the Institute of Electrical and Electronics Engineers, Inc. (IEEE). The IEEE is the world's largest technical/professional society, with over 165,000 U.S. members, representing all disciplines of electrical and electronics engineering. In 1980, the IEEE founded its Research and Development Committee, a mechanism through which the Institute formulates and voices its concerns on federal research and development funding and policies.

We appear before you this morning to comment on the potential impacts of the Reagan Administration cutbacks in federal research and development funding. It is difficult to do more than speculate when the nation is only little more than two months into the FY 1982 budget, where the bulk of these cuts first appear, and the total budget for 1982 has yet to emerge from the Congress. We will, nevertheless, try to draw some inferences from the trends we have witnessed over the past year.

U.S. Science and Technology Posture

One of the most important issues facing the United States today is the continuing economic vitality of the nation. It is important not only to our own citizens, but also for people throughout the world who are dependent on our technology to provide needed goods and services. We recognize the threat which inflation poses to our economic vitality, and we support measures to curb it.

We believe that technology is the key to economic vitality. Technology must be effectively utilized and advanced to provide better products and services, using labor, capital, and raw materials more efficiently than ever before.

Since World War II, the U.S. has been a technological leader, but technological leadership is not a static condition. It requires continual attention and dedicated effort. If we fail to continue to improve and move forward, we will be challenged and overtaken in specific areas, as is evidenced by the very significant Japanese and Western European competition in steel, automobiles, consumer electronics and a variety of other products.

Administration Philosophy

The philosophy of the Administration has been that the federal government should confine its research activities to long term, high risk

ventures, which industry is unlikely to fund. Industry, in turn, is expected to fill the gap caused by reduced Federal research as a result of tax incentives for increased R&D spending which accompanied the budget reductions passed earlier this year. These incentives provide for up to a 15% write off for internal R&D expenditures which exceed a company's average R&D funding for the preceeding three years. Additional incentives include tax reductions on equipment donations and contributions to non-profit institutions.

The 15% write off for internal R&D expenditures exceeding a three year average at best makes no distinction between short term and long term R&D activities, and may possibly provide a disincentive toward long term R&D. For example, a company only benefits from that proportion of its current R&D expenditures which exceed the three year average. Long term R&D which is not expected to pay off for three or more years would raise the average, and would thus seem to reduce the tax advantage. As a result, one could expect that any increases in corporate R&D would be for short term, product oriented research. With industry focusing on short term R&D, much of the cuts in federal funding for basic research will result in the termination of many important research efforts.

For example, one area of severe cutbacks has been NASA. Because of the mission needs of the U.S. Space program, major advances have been made

in numerous electronics technologies, including computers, communications, control and guidance, as well as remote sensing. These technological advances have been the foundations of major high technology industries which contribute substantially to our nation's economy and trade balance. During the development of the Space Shuttle, however, many opportunities and new initiatives have been delayed or deferred, and overall funding for the civilian space program has been severely constrained. While the communications sector is at the forefront of commercializing many near earth satellite technologies, many of the NASA programs being impacted by budget cuts are in basic research, such as the Planetary Program. There is virtually no chance of the private sector supporting such initiatives. The research gaps which result from the cutbacks in government funding will almost certainly impact our future leadership position in space science.

Another problem is the need of our universities to upgrade their research facilities. Providing tax credits to industry for equipment donations to non-profit research institutions may help the generally recognized problem of outdated university research equipment. But can such donations be relied upon to provide sufficiently meaningful research opportunities to attract more graduate students and faculty?

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Generally, then, we would identify three problems with the Reagan Administration's approach to research. First, reductions in federal support for long-term, basic research will almost certainly result in a loss of much of this research, because industry has no incentive to contribute to it. Second, it appears doubtful that current incentives for industry to increase support to the universities will enable the badly needed upgrading of university research facilities. Finally, even if industry is ultimately able to replace the reduction in federal support of university research facilities, the time lag may well cause major disruptions in graduate curricula, impacting the quality of these graduate programs.

We appreciate this opportunity to share our views with you this morning, and would be most happy to provide you with any further information we can in support of your deliberations.

Mr. ERTEL. Thank you very much, Mr. Haas, for your statement. I would just like to say one thing initially. IEEE has provided me with a science fellow this year, and at your expense. That to me, has been one of the greatest assets we have had in our staff. I wanted to commend you and your Institute for that. I think it is a tremendous program you have.

Mr. HAAS. Thank you. I believe that is a very worthwhile program for IEEE.

Mr. ERTEL. But, unfortunately, that doesn't make up for all the other moneys that are going to be misallocated, it seems to me, within the Federal Government, which you already pointed out in your statement.

One thing that bothered me—you said that other countries will have more money allocated to space applications than the United States?

Mr. HAAS. I believe that the Japanese space program and the program of ESA, European Space Agency, will address the applications' activities or space activities to a higher extent than we are in this country, yes.

Mr. ERTEL. I assume that gives you pause, as it does me.

Mr. HAAS. I think it is not a very creditable direction for our country to take, and I believe that the space program over the years, until it started to reduce its new starts, I think, provided a great impetus for the technologies that we are talking about here today. I believe that the image of this country was very important for students coming out of the high schools and entering colleges. And I think that we have seen a decrease in enrollment in the technologies, probably to some extent caused by our lack of interest and enthusiasm in continuing with the space program. I sincerely believe that.

Mr. ERTEL. Last week the President's science advisor, Dr. Keyworth, testified that in many areas, the United States is equal to anyone else in the world. A few years ago that statement would probably have been something like this—In most areas, the United States is pre-eminent. Dr. Keyworth has told the Congress that the United States can no longer afford to be the best in all scientific areas anymore.

Do you agree with this attitude? And, if so, which areas can we cast aside?

Mr. HAAS. Well, he may be right in the statement that we cannot afford to be the best in all, but I suspect and I believe that we are moving in the direction where we will not be the best in any. And that is certainly something to give a person a chance to reflect on the direction we are moving.

It used to be, not too many years ago, we believed that the Japanese were very good at copying our technology. And I think recent history certainly shows that they have approached the investment of high technology, new technology, from both the Government and industry point of view to result in products which gave their nation singular success in many different areas.

I have a few examples in my own particular area of business expertise, where the Japanese Government together with their industrial concerns decided to make an effort in an area called Gallium Arsenide technology, in which we are now beginning to catch up to

the Japanese. However, they still provide to the world, the most highly qualified products in field effect transistors made of this. That is just one particular example of where they have chosen to single out a particular field of technology and move ahead.

Mr. SHAMANSKY. If I may, Mr. Chairman, I would like to comment. We have heard a lot of testimony in our committee during the past year on productivity and research and this and that. It seems to me that one of our failures is purely merchandising. That is, determining what the public wants as opposed to abstraction. The Japanese, it seems to me, have simply beat us at our own game. Namely, selling what people want to buy. So it is not enough just to talk about having to improve our productivity, if nobody wants to buy the item we are producing after we produce it more efficiently.

That is something that you scientists and engineers cannot handle. The business community ought to look to itself in that area.

Dr. BRANSON. Mr. Shamansky, have you ever thought, sir, it might be unfortunate if we tied certain basic things too tightly to a profit motive in this regard. Every major Nation must make a decision about certain things it will do, irrespective of whether or not they can be done with a profit coming to someone else.

Maybe the tragic thing here is that we are trying to make all of these, and we are cutting out great things that this Nation should be doing. Our camera optical industry, for example, has gone to pot. We do not have any anymore. And you look at other things. In computers, we have now, because somebody else is not thinking of making a profit right now, but is willing to invest and carry forward. It is a very, very simple idea.

In other words, the social arithmetic which is being encountered is faulty.

Mr. ERTEL. Congressman Walgren.

Mr. WALGREN. I wanted to ask a question of Dr. Branson. We have in NSF a program, hopefully, to provide a little affirmative action with respect to minorities. Have you found that to be helpful?

Dr. BRANSON. Very helpful, sir. But it was mistreated recently. It was moved out of NSF. For example, things like MISIP, which was extremely valuable and doing a fine job was moved over to the Department of Education. And the latest news coming from there is that the whole agency is apt to be killed. We find that very, very harmful, very, very frightening.

And what we are saying is that there have been many very good things. For example, title III, which was devised in order to aid developing institutions. We find that we are getting very little support, however, to insure that it is going to these institutions we are talking about. As a matter of fact, others are coming in and trying to move those funds away. So there are many things. That is why we need your active concern to see that this number or these people are taken care of.

Mr. WALGREN. Well, I particularly want to express my appreciation for the statistics that you presented, Dr. Branson. We went through the authorization of NSF in great detail, and thinking back on all that hearing, including the authorization for the

women and minorities program, I never remember being as struck by the facts, as I have in hearing your presentation. So you have struck a real chord with me.

Dr. BRANSON. Thank you, sir.

Mr. WALGREN. And one that will have a lasting effect with the committee, if I have any way to effect that, so I appreciate your testimony very much.

Dr. BRANSON. Thank you very much.

Mr. WALGREN. You know, I just cannot get over the way that we have not realized the investment nature of the scientific enterprise, not only with respect to minorities, but in the broader nature of science. It is just amazing to me to realize how the administration has failed to recognize the investment nature of these efforts. And I will never forget in the authorization program, when the authorization was under consideration on the floor of the House, someone got up as a spokesman for the administration and said—Let us show the private community that we are going to increase investment by showing them that we are going to cut Government spending, so let us cut the National Science Foundation.

Well, nothing could be further from the truth when you actually look at what the the National Science Foundation expenditures are used for. I just can't get over the fact that the administration wants to increase investment and yet their program decreases investment. It is just nonsensical. I am afraid it goes back to the concept of supply side economics attempting to balance the budget by unbalancing the budget. And it is as plain as that.

I do want to express my appreciation for people coming forward and expressing their opinions on the unmet needs. I do believe that until our political body understands the nature of the balance that we have to strike to enhance both our productivity and our investments, there will be essential needs that will not be fulfilled, and we will suffer from this.

So I just want to express my appreciation for your testimony. Mr. Haas, is it Dr. Haas or Mr. Haas?

Mr. HAAS. Mr. Haas.

Mr. WALGREN. I want to say you are lucky, Mr. Haas. The Congressmen who have preceded me, never used first names. He always addressed people as Dear Haas. At least you get a Mister.

Mr. ERTEL. Thank you very much, Doug. Mr. Haas, you never did answer the second part of my question. We are not going to be pre-eminent in all areas of space or all areas of education. Which areas do you suggest we cast aside if we accept the Keyworth statement? That may be a bad question. It is like—When do you stop beating your wife? There is really no area, I think, we ought to cast aside really. Maybe that is your answer. Or is there an area we ought to cast aside?

Mr. HAAS. I do not believe that one exists. I think that in order for us to be a whole and to continue as a nation in technological leadership, we must consider every facet of technology and every facet of education. I do not believe that we can afford to neglect any. The question of how many should be superior, that is a tough question to answer. But certainly enough to maintain a position of leadership in the world. And it is not apparent that we are moving in that direction. If we look at the things that have been happening

in the past administration and current administration, there are severe areas of neglect, which I believe help to stimulate this country and to keep it moving in the right direction.

Mr. ERTEL. I think Dr. Branson has already answered that question in his eloquent statement, so I will not come back and ask him again.

But we do appreciate both of your testimonies. We thought it was very helpful, especially on the minority position and what is happening in the science field. I think that is very illuminating. We appreciate your coming all the way from Lincoln University. Dr. Branson. We appreciate your coming, too, Mr. Haas. I guess you came from Philadelphia, pretty much the same distance.

Mr. HAAS. That is right.

Mr. ERTEL. So we appreciate your testimony. Thank you very much, gentlemen. At this point the subcommittee will stand adjourned.

[Whereupon at 11:35 a.m., the subcommittee was adjourned.]